Electrical Equipment of the Colgate Power House

STANFORD UNIVERSITY LIBRARY MAY 15 1902

The Journal of ELECTRICITY POWER AND GAS

DEVOTED TO THE CONVERSION, TRANSMISSION AND DISTRIBUTION OF ENERGY.

Price of this issue 20 cents

VOL. XII.—No. 4. SAN FRANCISCO, CAL., APRIL, 1902. YEARLY SUBSCRIPTION $1.00 SINGLE COPIES, - VARIABLE

1889 PARIS EXPOSITION MEDAL FOR RUBBER INSULATION

OKONITE TRADE MARK

1893 WORLD'S FAIR MEDAL FOR RUBBER INSULATION

SOLE MANUFACTURERS OF

OKONITE TAPE : MANSON TAPE

CANDEE WEATHER-PROOF WIRES

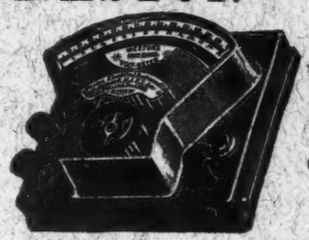
THE OKONITE COMPANY, Ltd.,

Willard H. Candee, H. Durant Cheever } Managers
Geo. T. Manson, General Superintendent
W. H. Hodgins, Secretary

253 Broadway, NEW YORK.

WESTON ELECTRICAL INSTRUMENT CO.,

Waverly Park, Newark, N. J., U. S. A.



Weston Standard Portable Direct Reading VOLTMETERS, MILLIVOLTMETERS, VOLTAMMETERS, AMMETERS, MILLIAMMETERS, GROUND DETECTORS and CIRCUIT TESTERS, OHMMETERS, PORTABLE GALVANOMETERS.

Our Portable Instruments are Recognized as the STANDARD the world over. The SEMI-PORTABLE LABORATORY STANDARDS are still better. Our STATION VOLTMETERS and AMMETERS are unsurpassed in point of extreme accuracy and lowest consumption of energy.

BERLIN: European Weston Electrical Instrument Co., Ritterstrasse, 84.
LONDON: Elliott Bros., 101 St. Martins Lane.

NEW YORK STANDARD UNDERGROUND CABLE CO.

BOSTON FIBER PAPER RUBBER CABLES

PHILADELPHIA PITTSBURG TELEPHONE ELECTRIC LIGHT AND POWER CABLES

CHICAGO SAN FRANCISCO HIGH GRADE RUBBER AND WEATHER PROOF WIRES

Inquire about the work we have done and the thousands of miles of Feeder Cables (aerial and underground) we have furnished and installed for electric railway and other companies. The replies will interest you.

Factories at Perth Amboy, N. J., Pittsburg, Pa., and Oakland, Cal.

Pacific Coast Sales Agent, CHAS. F. SLOANE, Room 1, Second Floor, MILLS BUILDING, San Francisco

Manufacturers of the STANDARD ELECTRICAL APPARATUS of the World

General Electric Company Schenectady, N. Y.

DYNAMOS AND COMPLETE PLANTS

FOR ALL ELECTRIC SERVICES

Lighting, Railway, Mill, Factory or Mining, Power Transmission.

The GREATEST ELECTRIC INSTALLATIONS in the world are EQUIPPED WITH G. E. APPARATUS.

1000 H. P. DYNAMO

Claus Spreckels Building, SAN FRANCISCO, CAL.

Worcester Building, PORTLAND, OR.

When writing advertisers kindly mention "The Journal of Electricity, Power and Gas."

Northern Electrical Manufacturing Company

MADISON, WIS.

NORTHERN GENERATORS are RUGGED and SUBSTANTIAL but Clean Cut and Symmetrical

For Belt or Engine Drive

Designed and built with the idea that the purchaser wants a machine which will live as long as he does. In truth, we think some of these self-same machines will be passed on to sons and grandsons. Northern motors are built on the same principle. If you would like a little more light on the matter write for Bulletin No. 926.

We have made some of the largest installations for complete electric drives in America, and challenge a comparison of economical working.

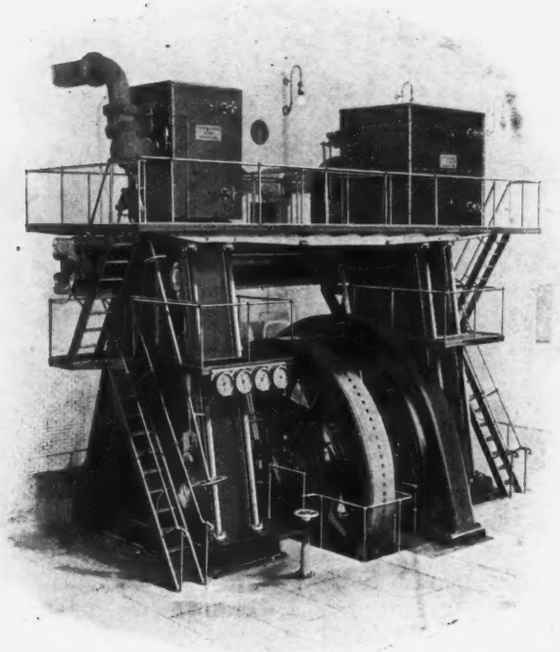
We build all sizes of generators and motors for either alternating or direct current.

JNO. MARTIN & CO. Pacific Coast Agents

Pioneer Bldg, Seattle, Wash. 31-33 New Montgomery St., San Francisco, Cal.

511 Douglas Building, Los Angeles.

THE EXECUTION OF AN ENTIRE CONTRACT FROM START TO FINISH UNDER ONE MANAGEMENT INSURES BEST RESULTS



POWER, LIGHTING, HEATING AND PUMPING PLANTS
.....MACHINERY OF THE HIGHEST GRADES... .....

CHAS. C. MOORE & CO...
ENGINEERS
CONTRACTORS FOR
COMPLETE POWER PLANTS

Our Machinery is the First Choice of the Engineer

MAIN OFFICE
32 FIRST ST.
San Francisco, Cal.

BRANCH OFFICES
LOS ANGELES
SEATTLE

Best by Test!
TUTTHILL WATER WHEELS
Adaptable to All Speeds and Heads
High in Efficiency! Low in Cost!
Write for our 1900 Water Wheel Catalogue. It is replete with hydraulic data and—gratis.

OAKLAND IRON WORKS
Business Office:
330 Market Street, San Francisco.
'Phone, Main 1007.
Works—Second and Jefferson Streets, Oakland. 'Phone, Main 342.

GEORGE E. CARTER & CO.
Room 28, Crocker Building
SAN FRANCISCO
Telephone Bush 481
Quotations Furnished in Lots and Sizes to Suit Demands.

SQUARE SAWN REDWOOD
ROUND RED CEDAR
Poles
and Pine Cross Arms

PROFESSIONAL.

EDWARD S. COBB
Designing and Consulting
MECHANICAL AND HYDRAULIC ENGINEER
Plans, Estimates, Specifications, Tests, Supervision of Construction
Room 223, Homer Laughlin Bldg.,
315 South Broadway, Los Angeles, Cal.

ROBERT McF. DOBLE
Mechanical and Electrical Engineer
Consultation
Supervision
Constructing
314 HAYWARD BUILDING
SAN FRANCISCO

LEON M. HALL
CONSULTING ENGINEER
IN MECHANICS, ELECTRICITY, MINING.
814 Hayward Building San Francisco
Telephone, MAIN 989

ENGINEERING OFFICES
331 Pine Street, : San Francisco, Cal.
E. H. Benjamin, Mining Engineer
A. M. Hunt, Mechanical and Hydraulic Engineer
Wynn Meredith, Electrical Engineer
C. L. Cory, Electrical and Mechanical Engineer
Wyatt H. Allen, Electrical Engineer.
Expert Examinations: Advisory Reports: Construction Supervision
Telephone, Main 1870. Cable address, "Edben."

FRANK E. SMITH
Consulting and Supervising
Electrical Engineer
418 Eugenia Ave, 'Phone, Blue 751 San Francisco

FRANK H. BATES
CHEMICAL and GAS ENGINEER
With Chas. C. Moore & Co., 32 First St., San Francisco
Westinghouse Gas and Oil Engines installed for use with natural, illuminating, and producer gas, gasoline, distillate or crude oils, and in single units as large as 750 horsepower.
Contracts taken for complete Gas Producer and Engine Installations for electric light or other service, with absolute guarantees as to regulation, economy and durability.

R. S. MASSON
Consulting
Electrical
Engineer
Crocker Building San Francisco, Cal.

FRANK P. MEDINA
Attorney-at-Law
Counselor in Causes Involving the Law of Electricity
Electrical Patents a Specialty
Room 7, Hobart Building
Phone Bush 477
532 Market Street
San Francisco, Cal.

A WATER POWER OR LONG DISTANCE TRANSMISSION PLANT EQUIPPED WITH A BATTERY OF
"Chloride Accumulators"
can be relied upon to give GOOD REGULATION and CONTINUOUS SERVICE
THE ELECTRIC STORAGE BATTERY CO.

Sales Offices
Philadelphia New York Boston
Chicago Baltimore Cleveland
St. Louis Detroit
SAN FRANCISCO: Nevada Block
Detailed description of installations forwarded upon request.

When writing advertisers kindly mention "The Journal of Electricity, Power and Gas."

NATIONAL TUBE COMPANY,

MANUFACTURERS OF

High-Pressure Pipe Lines.

We manufacture lap-welded pipe and receivers for power lines up to 30 inches diameter, with lead joints, expanded and riveted joints, cast-iron or rolled-steel flange joints, or solid welded flange joints.

We also manufacture a full line of welded and seamless tubular goods.

LAP-WELDED PIPE only is used for extreme pressures. Among those using our pipe lines for this purpose may be mentioned the following California companies:

San Joaquin Electric Co.	20-inch pipe,	1411	head,	612	lbs.	pressure.
Blue Lakes Water Co.	22 " "	1040	"	451	"	"
Mt. Whitney Power Co.	20 " "	1300	"	574	"	"
Standard Electric Co. of California ...	30 " "	1485	"	640	"	"

California Sales Office, No. 420 California Street, San Francisco, Cal.

IMPERIAL PORCELAIN

HIGH-POTENTIAL INSULATORS

Manufactured by Imperial Porcelain Works.

TRADE MARK IMPERIAL PORCELAIN

These Insulators are in exclusive use on such important power transmission lines as:

SOUTHERN CALIFORNIA POWER CO., - - - *Redlands to Los Angeles*

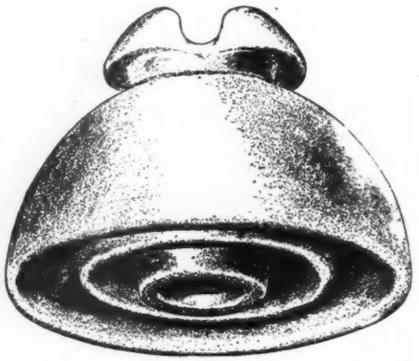
SNOQUALMIE FALLS POWER CO., - - - - - - *Snoqualmie Falls to Seattle and Tacoma*

WEST KOOTENAY POWER AND LIGHT CO., - - - - - - *Bonnington Falls to Rossland*

NIAGARA FALLS POWER CO., - - - - - - *Niagara Falls to Buffalo*

HUDSON RIVER POWER TRANSMISSION CO., - - - - - - *Mechanicville to Schenectaay*

and many others.



Eight Different Types—All Voltages.

Address all correspondence to

C. L. Knowles.

General Sales Agent

7 Arch Street,

BOSTON, MASS.

JOHN A. ROEBLING'S SONS COMPANY

TRENTON, N. J.

MAKERS OF **WIRE ROPE** AND OF . . .

Bare and Insulated Copper Wires and Cables for All Electrical Purposes

25-27 FREMONT STREET, SAN FRANCISCO, CAL.

Telephone Private Exchange 67

LIGHTEN THE "WHITE MAN'S BURDEN"

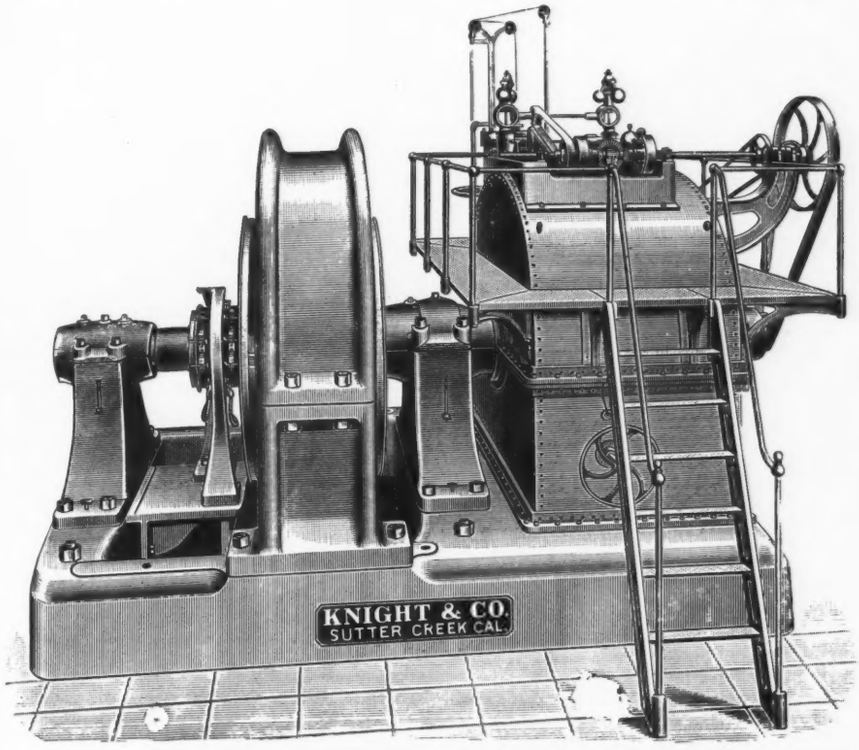
The fireman will rejoice and it won't matter much to the coal man if you cut him 5 or 10 % now that business is good.

(Clean Boilers.) Try it. **DEARBORN FEED WATER TREATMENT**

SEND A GALLON JUG OF WATER FOR ANALYSIS.

Dearborn Drug and Chemical Works, WM. H. EDGAR, President. **29-33 Rialto Bldg., Chicago, Ill.**

KNIGHT'S * WATER * WHEEL



The accompanying cut shows the general arrangement of KNIGHT'S STANDARD WATER WHEEL, of which there are HUNDREDS IN USE in different States of the Union. These wheels are made from 2 to 6 feet in diameter, from 10 to 1000 horse power, and adapted to all heads and purposes. Wheels inclosed in iron cases from 6 to 24 inches. Wheels for electrical power can be furnished with or without Governors. Highest regulation guaranteed. Address all communications to

For full particulars send for descriptive catalogue.

KNIGHT & CO., Sutter Creek, Cal.

ADVERTISERS' INDEX.

	PAGE
Abner Doble Company	xiii
Bates, F. H.	iii
Benjamin, Edward H	iii
Bullock Electric Manufacturing Co	vi
Burch, Edward P	iii
Byron Jackson Machine Works	vii
California Electrical Works	vii
California Incandescent Lamp Co	xi
Carter, & Co., George E	iii
Century Electric Co.	v
Cobb, Edward S	iii
Cole, John R	vi
Cory, C. L	iii
Crocker Wheeler Co	vi
Crosscup, I. O	vii
Crouse-Hinds Electric Co	xv
Dearborn Drug and Chemical Works	v
Doble, Robert McF	ii
Electric Storage Battery Co	iii
General Electric Company	i
Hall, Leon M	iii
Hardwood Planing Mill Co	x
Heald's School of Engineering	v
Hunt, A. M.	iii
Joseph Dixon Crucible Co	x
Knight & Co.	v
Knowles, C. S	iv
Locke, Fred M	vii
Lombard Governor Co	ix
Martin & Co., Jno	vii, viii, xvi
Masson, R. S	iii
Medina, Frank P	iii
Meredith, Wynn	iii
Moore & Co., Chas. C	iii
National Tube Company	iv
New York Insulated Wire Co., The	x
New York Lubricating Oil Co	vi
Northern Electrical Mfg. Co	ii
Oakland Iron Works	iii
Okonite Company, Ltd., The	i
Pacific Electrical Works	ix
Paraffine Paint Company, The	vii
Pass & Seymour	xv
Pelton Water Wheel Company	xii
Pittsburgh Reduction Company	viii
Ridley, A. E. Brooke	vi
Risdon Iron Works	x
Roebling's Sons Co, John A	iv
Sloane, Chas. F	i, xi, xv
Smith, F. E.	iii
Stanley Electric Manufacturing Co.	xvi
Stanley Instrument Co.	v
Union Lumber Company	v
Van der Naillen School of Electricity	v
Westinghouse, Church, Kerr & Co	viii
Westinghouse Electric & Manufacturing Co	viii
Westinghouse Machine Co	viii
Weston Electrical Instrument Co	i
Worthington, Henry R.	xiv

REDWOOD POLES

For TELEGRAPH
TELEPHONE
ELECTRIC LIGHT
POWER PLANTS

In lots and sizes to suit at short notice

Union Lumber Company

TELEPHONE, "MAIN 324"

Rooms 206-207, Crocker Building, San Francisco

CENTURY ELECTRIC CO.

ENGINEERS
AND
CONTRACTORS

18 Second St., - SAN FRANCISCO

Telephone, BUSH 352

Pacific Coast Agents for
ELECTRICAL INSULATING CONDUIT CO.,
Write for information and prices

Stanley A. C. Wattmeters

Permanent Accuracy Guaranteed

STANLEY INSTRUMENT COMPANY

San Francisco, 31-33 New Montgomery St.

SEATTLE, WASH., Pioneer Building

NEW YORK: 146 Broadway.

LOS ANGELES: 511 Douglas Building.

?

Do you read THE JOURNAL OF ELECTRICITY, POWER AND GAS? If you don't, now is the time to subscribe. $1.00 144 Union Square Avenue, San Francisco, Cal.

—SCHOOL OF—

PRACTICAL ENGINEERING

(ELECTRICAL, CIVIL, MINING AND MECHANICAL)

Surveying, Drawing, Architecture and Assaying.

113 Fulton St., : : San Francisco

(One block above New City Hall)

A. VAN DER NAILLEN, President

Send for circulars Established 1864

HEALD'S

BUSINESS COLLEGE
—AND—
SCHOOL OF ENGINEERING

Electrical Engineering Department
ORION BROOKS, Instructor.

Mining and Assaying Department
G. W. MILES, M. S., Instructor.

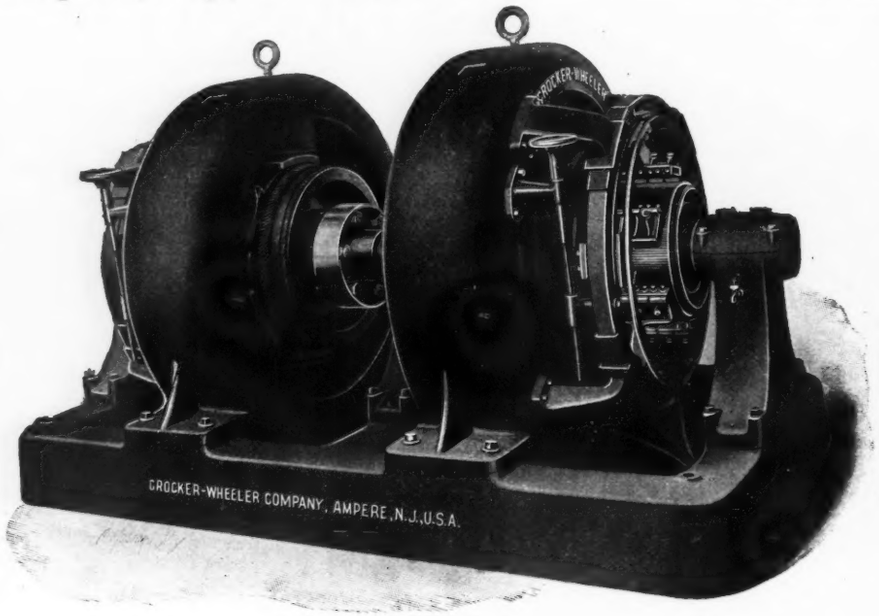
24 Post Street, San Francisco.

Crocker-Wheeler Company

Manufacturers and Electrical Engineers

Main Office and Works
Ampere, N. J., - - U. S. A.

San Francisco Office
Abner Doble & Co., Managers



Railway Booster

RAILWAY BOOSTERS

The great extension of electric railway systems, involving the transmission and distribution of electric power over great distances and large areas, has resulted in a general use of Motor-Dynamos in combination with various methods for compensating for line losses and equalizing load fluctuations.

The **Crocker-Wheeler Company** has made a special feature of the design and construction of Motor-Dynamos for such purposes, and our experience covers a wide variety of forms.

Denver Office
624 Cooper Building

BULLOCK ELECTRIC MFG. CO.
Cincinnati, U. S. A.

Direct and Alternating Current Equipments for Electric Light and Power . . . . .

287

The Half Tone Co.

Manufacturers of

Printing Plates

By All Processes

144 Union Square Avenue, Fifth Floor
SAN FRANCISCO, CAL.

Positively the finest work produced on the Pacific Coast
See half tone cuts in this issue

New York Lubricating Oil Company Manufacturers and dealers in HIGH-GRADE LUBRICANTS

MARINE, ENGINE, RAILROAD, CYLINDER and the . . . . . **I. S. C. TRANSFORMER OIL**

530 California Street, SAN FRANCISCO (Rooms 3 and 5) 35 Water St., New York

---

A. E. BROOKE RIDLEY

ELECTRICAL ENGINEER and CONTRACTOR. . . .

597-599½ Parrott Building
10 Front Street
San Francisco, Cal.

When writing advertisers kindly mention "The Journal of Electricity, Power and Gas."

POWER TRANSMISSION

Managers have no line troubles when using

Locke Insulators

VICTOR TYPE.....

Line Pressure 60,000 Volts.

Tested to 120,000 Volts.

PATENTED
Sept. 28, 1897
June 7, 1898
May 29, 1900
Other patents now pending.

Adopted by
STANDARD ELECTRIC COMPANY
Of California.

BAY COUNTIES POWER COMPANY.

On Longest Power Transmission Lines in the World

400,000 LOCKE INSULATORS in use on the Pacific Coast, Operating on Line Pressures up to 60,000 Volts. . . . . .

JNO. MARTIN & CO.

PACIFIC COAST AGENTS

31-33 New Montgomery Street, San Francisco.

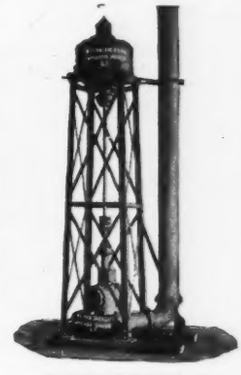
511 Douglas Building, Los Angeles. Pioneer Building, Seattle, Wash.

BYRON JACKSON MACHINE WORKS

Hydraulic Engineers

411 MARKET ST., SAN FRANCISCO, CAL.

Our Multiple Compound Centrifugal Pumps are Unequalled



Our Self-oiling Bell Ends For Vertical Electric Motors Insure success

MANUFACTURERS OF

High Head Direct Connected High Speed

ELECTRICALLY DRIVEN PUMPING MACHINERY

Branch Office——201 North Main St.——Los Angeles, Cal.

Emerson Fan Motors

ALTERNATING CURRENT
DESK AND CEILING FANS

WRITE FOR CATALOGUE AND PRICES

California Electrical Works

547 MISSION STREET TELEPHONE PRIVATE EXCHANGE 144 **SAN FRANCISCO, CAL.**

CROSSCUP'S XXX BOILER COMPOUND

Is guaranteed

To remove and prevent scale;
To stop and prevent pitting and corrosion;
To stop priming, and keep boilers in first-class condition for less cost per horsepower than any other compound on the market.

All orders promptly filled by

I. O. CROSSCUP,

123 California Street, Room 500. 'Phone Davis 848. San Francisco

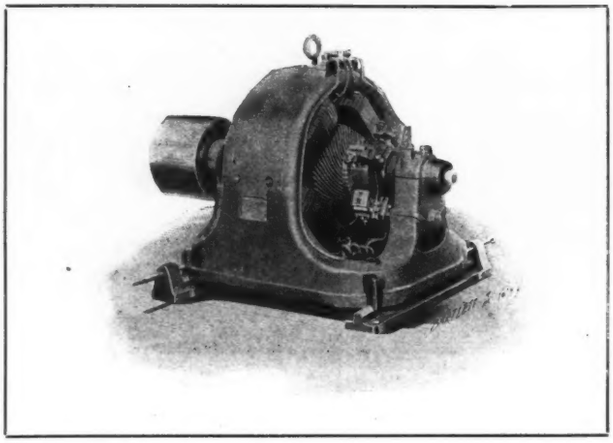
In cases of Insulation

Use **P & B** Paint
Building Paper or
Ready Roofing

These articles are made to withstand the injurious effects of water, heat, gases, vermin, rats and mice. They are non-conductors and can be used advantageously about electrical works or construction of all kinds. *Write for booklets—address dept. J.*

PARAFFINE PAINT COMPANY
116 Battery Street : : San Francisco

Westinghouse Multipolar



motors will save you space, labor, time and money in many classes of work. For pumping, hoisting, tool-driving and general power service eminently satisfactory. Thousands of motors in service show this.

Write for Circular 1042

Westinghouse Electric & Mfg. Co.,
Pittsburg, Pa.

Sales Offices: San Francisco, Seattle, Los Angeles, Mountain Electric Co., Denver, And all other large cities

---

Westinghouse, Church, Kerr & Co.,
ENGINEERS
Westinghouse Gas and Steam Engines, Mechanical Stokers, Steam Turbines, Etc.
Designed and Built by
The Westinghouse Machine Co.,
Pittsburg—Chicago
Write nearest office of Westinghouse, Church, Kerr & Co.

New York
Pittsburg
Chicago
Boston
Philadelphia
Detroit

36D

Aluminum Railway Feeders

ALUMINUM feeders are less than one-half the weight of copper feeders and are of equal conductivity and strength.

Joints of aluminum feeders can be easily, cheaply and satisfactorily made.

If wire or cable is required to be insulated, high-grade insulation is guaranteed.

Price-list with full information furnished on application.

The Pittsburgh Reduction Co.
PITTSBURGH, PA.

PACIFIC COAST AGENTS:

JNO. MARTIN & CO.
31-33 New Montgomery St.,
SAN FRANCISCO, CAL.
511 Douglas Bldg, Los Angeles. Pioneer Bldg, Seattle, Wash.

Power-Transmission, Telephone and Telegraph Wire

When writing advertisers kindly mention "The Journal of Electricity, Power and Gas."

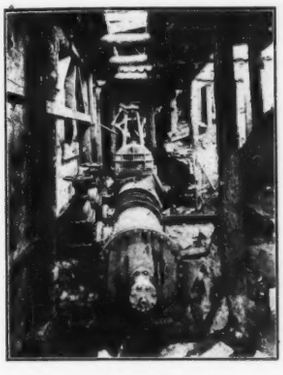
EDWARD C. JONES.

THE JOURNAL OF ELECTRICITY, POWER AND GAS.

Devoted to the Conversion, Transmission and Distribution of Energy.

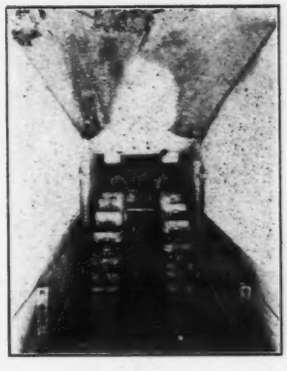
VOLUME XII. SAN FRANCISCO, APRIL, 1902. NUMBER 4

The Electrical Equipment of the Colgate Power House.



THE MAIN GATE VALVES.

FEATURES of unusual engineering interest abound on every hand in the equipment of the great power house of the Bay Counties Power Company at Colgate, where a comparatively small portion of the mechanical energy of the mighty Yuba is converted into electricity for transmission over far greater distances than even the most sanguine enthusiast believed to be possible but two or three years ago. The relation of the achievements of the engineers of this epoch-making enterprise—achievements made possible through the far sightedness, acumen and indomitable courage of its promotors, managers and financial supporters—have been related so fully in these columns heretofore that now naught remains to tell but the story of the chief electrical features of the power house, which is above all others the present cynosure of the eyes of the electrical transmission world in every clime.



IN A 3000-H. P. RISDON WHEEL PIT.

It is not venturesome to predict that procedures which a brief time since were deemed experimental, but which have now through the energy of the Bay Counties Power Company been demonstrated as eminently practicable and commercially feasible, will quickly become adopted as standard in extreme long distance high tension transmission work; indeed, the prophesies made in these columns many, many months ago, to the effect that virtual empires of productive communities in California would be eventually linked together through the medium of electric power transmission into a single mighty system wherein electricity and gas, water power and steam power, would be united into a harmonious whole—these prophesies, so often dwelt upon, are now far more near actual fulfillment than many others that have been regarded as being indubitably less visionary.

And so, much interest will be attached to the subjoined description of the principal electrical features of the Colgate power house, marking as it does a closing chapter of this serial which has been devoted to a mighty undertaking. That much more is to be said upon the subject is not to be questioned, for more is bound to appear in the columns of THE JOURNAL upon every type of never ending engineering interest, but the following able article by Messrs. Heitmann and Currie (some of which has appeared in "The Engineering News") fittingly concludes the descriptive features of the serial in hand.—THE EDITOR.

"S. K. C." APPARATUS AT COLGATE.

BY EDW. HEITMANN AND WM. CURRIE.

IN general, the most important factors to be considered in selecting alternating current generators are high efficiencies at all loads, low heating, good regulation, thorough insulation and easy accessibility for quick repairs. While all of these features should receive due consideration, the regulation becomes of prime importance. With the exception of the drop due to the line itself, that of the generator is the greatest of all the apparatus used in an electric transmission; therefore the total regulation of the system largely depends upon it. Moreover, the load will always be quite inductive, and, at the best, it is difficult to obtain close regulation under such conditions.

SCENES IN HYDRAULICKING RESEMBLING THOSE OF EARLY MINING DAYS ARE BEING ENACTED AT LAKE FRANCES.

GENERATORS. The two principal factors which determine the regulation of alternators are armature reaction and armature self-induction. It is desirable to keep the latter as small as possible in order to prevent an excessive rise in the voltage at low loads, due to the capacity current of the line. Hence it is important to not only have the regulation close but also to adopt a design which insures low armature self-induction.

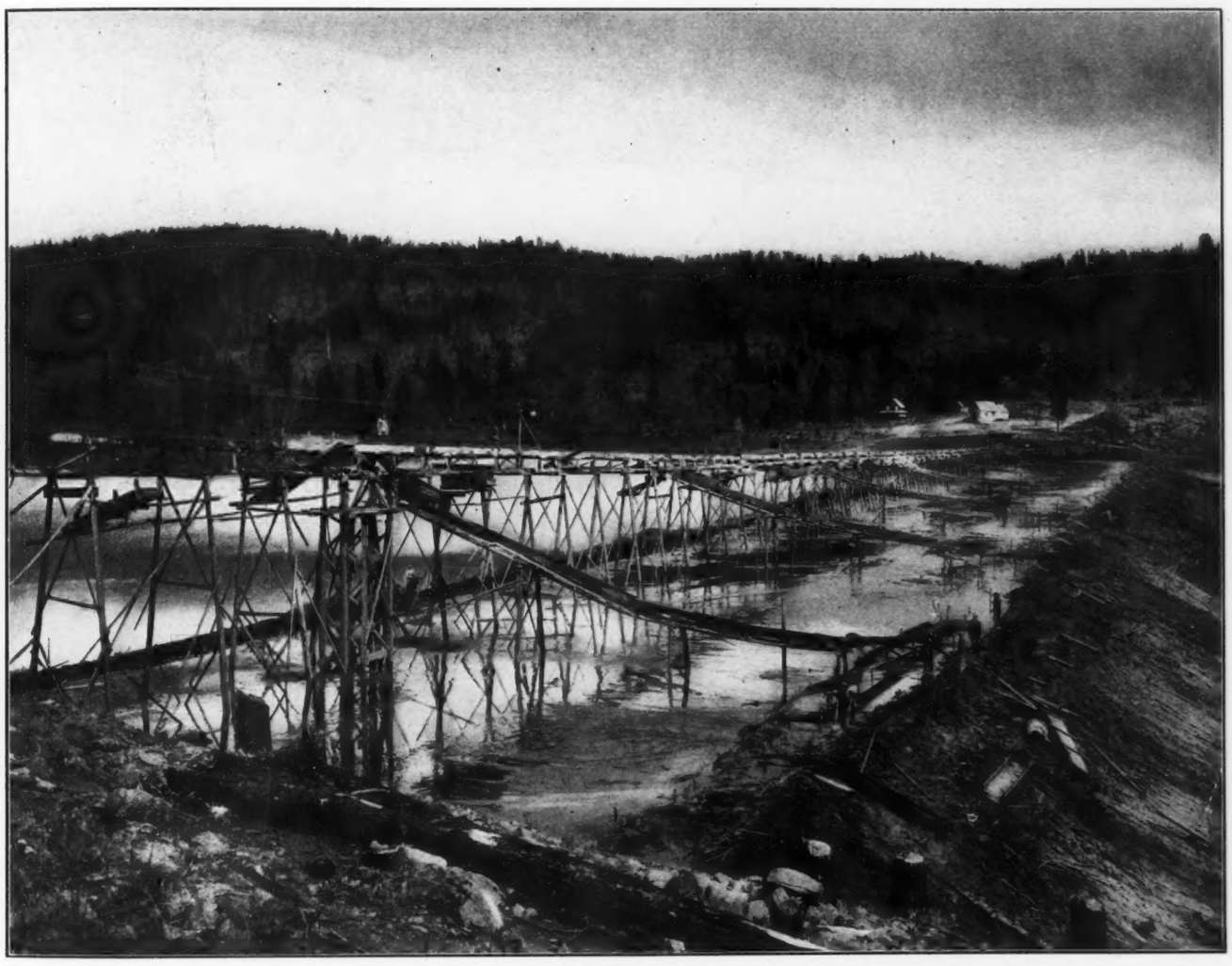
The heating at normal loads should be low, since the deterioration of the insulation depends largely upon it, and since this will also enable the generator to carry heavy loads if necessary with perfect safety.

The parts liable to injury must be few and readily accessible. Mechanically the design must be such that the machine will withstand either shocks due to excessive overloads or a greatly increased speed, which may become possible with a breaking down of the governing apparatus or a sudden decrease of load. The parts must also be limited in size and weight to permit of easy hauling over difficult roads and steep grades common to mountainous districts.

The peripheral velocity of water wheels of the Pelton type is usually about one-half the spouting velocity of the water. Therefore when such water wheels operating under high heads are used as prime movers, it generally becomes necessary to adopt high speeds in order to keep the wheels within reasonable dimensions. Hence, a design which can be used for high speeds and which embodies all the points enumerated, without becoming too bulky and costly, will at once recommend itself for this work. The inductor-alternator possesses all these features to a

marked degree. Its design and construction permits the use of extremely high peripheral speed, effecting good ventilation and therefore low heating, and makes it possible to utilize armatures of large diameters and narrow widths, both of which are great aids in obtaining low self-induction and good regulation.

All of these features can best be illustrated by a description and discussion of one of the generating units installed. While the Bay Counties company have a number of different sizes, their characteristics are in all respects similar. A description of one generator will therefore suffice. The largest of these consists of a 2000-kilowatt, 60 periods per second, 2200-volt, S. K. C. inductor-alternator, direct-connected to a Risdon water wheel operating at 240 revolutions per minute, as described in detail in THE JOURNAL for January last. These generators were built by the Stanley Electric Manufacturing Company of Pittsfield, Mass.



WHERE THE FILLING FOR THE DAM CONFINING THE RESERVOIR IS BEING SLUICED IN.

The revolving element, or inductor, consists of four cast-steel quarters (figure 6). The two quarters, which form one-half of the inductor, are clamped together at the hub by means of heavy bolts, and at the outer end of the spokes by means of rings shrunk on after installing. Bolts passing through the rim firmly unite the halves, which in addition are tongued and grooved on their inner surfaces. Projections to which the laminations that form the pole pieces are attached are cast on the face of the rim. The laminations are held in place by means of keys and dovetails. The inductor rotates at a speed of nearly 10,000 feet per minute; nevertheless, the fiber strains are such as to withstand an increase of 50 per cent. in speed with absolute safety. The inductor can be shipped in quarters if desired, one of these sections weighing approximately 13,000 pounds.

MECHANICAL CONSTRUCTION.

The pole punchings are shaped so as to cause a sine distribution of flux in the air gap. This, in connection with a low armature reaction and saturated teeth, insures a close approximation to a sine wave of electromotive force at all loads. Curves of the wave form under two conditions are shown in figures 8 and 9.

All the metal is cut away between the polar projections, and since with this type of machine no exciting coils are placed around the poles, these act like vanes on a fan and a large volume of air is forced through the armature and around the field coil, insuring a perfect and efficient ventilation.

The armature consists of a cast-steel ring, ribbed as shown, to the inner surface of which the armature punchings are fastened by means of dovetails and keys, similar to the inductor punchings. This armature is also made up of four quarters, each of which weighs approximately 7000 pounds with the winding and punchings.

Four half-inch ventilating spaces are inserted at equal distances in the armature. Openings are punched into this iron midway between each dovetail, which, when the iron is assembled, form ducts at right angles to the ventilating spaces. Holes are also bored in the outer casting at regular intervals around the periphery. Thus the entire construction permits of the best possible circulation of the air forced through by the inductor.

The armature winding is of the type known as a concentrated two-coil per slot winding. Each coil consists of a few conductors, wound edgeways, with mica insulation between the layers. The coil is wrapped in a special insulation, treated with an insulating compound and thoroughly baked after winding. The coils can be removed by loosening several clamps, after which they can be dropped down between the poles and withdrawn. It is, therefore, possible to remove an armature coil without disturbing any other part of the machine.

The field coil consists of a single stationary coil, made up of copper strip, wound in two sections, with a wide ventilating duct between them. The whole is surrounded by a heavy brass bobbin, which not only insures perfect rigidity, but also, due to its secondary action, prevents any possible breaking down of the insulation when discharging the field. Being situated between the armature halves its ventilation is thorough. On page 69 is shown a view of the assembled machine.

THE INCOMPLETED DAM AT LAKE FRANCES, SHOWING THE PIPE LINE LEADING TO THE PENSTOCK AT COLGATE.

The principal electrical characteristics are given in figure 10. Of these the most important are the curves showing the regulation, especially on inductive loads. These were calculated from data obtained from the shop tests. The full load regulations are as follows:

ELECTRICAL DATA.

For power factor 100 per cent. — regulation is 3.0 per cent.
" " " 90 " — " " 8.2 "
" " " 80 " — " " 11.0 "
" " " 70 " — " " 11.4 "

Thus the regulation on low power factor is extremely good, and the generator will have an inherent regulation

of 10 per cent., or better, for all loads likely to occur in such service.

The efficiencies, plotted in the same figure, were likewise calculated from shop tests, and are as follows:

125	per cent.	load	—	efficiency =	95.0 per cent.
100	"	"	—	" =	94.75 "
75	"	"	—	" =	93.5 "
50	"	"	—	" =	92.0 "
25	"	"	—	" =	89.0 "

The rise in temperature for the continuous full load running is 35 degrees centigrade for all windings. The generator will also carry 125 per cent. load continuously, with a temperature rise of 45 degrees centigrade, and 150 per cent. load for four hours without dangerous heating.

The results show that the generator will meet all the electrical requirements in a more than satisfactory manner.

Figure 8 gives a curve of electromotive force showing the no load wave form of this generator. It closely approximates a sine curve and retains this form with but slight modifications for all loads.

Figure 9 gives curves of simultaneous electromotive force and current taken with the oscillograph by Mr. E. E. Farmer at Piedmont station, Oakland, which is the terminus of the 143 mile line of the Bay Counties Power Company. The curve of electromotive force shows the impressed wave-form, which is but very little distorted and shows the effect of the line of capacity in peaking the wave.

The current curve has extra waves at the top and is a little in advance. These extra waves were caused by the reaction of the synchronous motor into which the line was feeding. The motor is a three-phase 550-kilowatt motor made by the General Electric Company. It was subsequently run as a generator, and the curve of free electromotive force taken. This curve was of the same general form as the current curve. It is a striking example indicating the advisability of choosing a synchronous motor having the same wave form as the generator.

THE LATEST VIEW OF THE INTERIOR OF THE COLGATE POWER HOUSE.

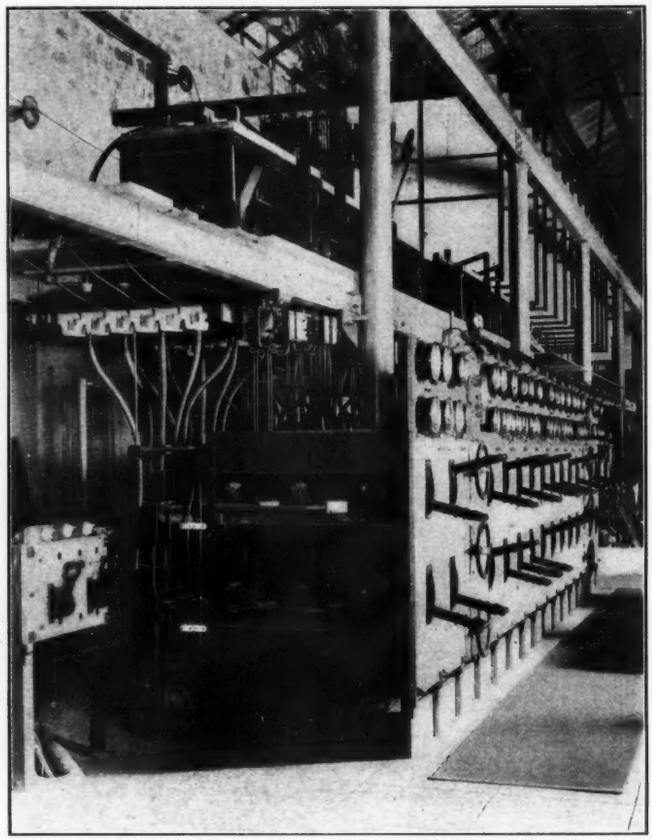
There has been published in an article by Mr. Edward Heitmann* a discussion of some very important considerations regarding the performance of inductor alternators, for although it has been in use for many years, and has given universal satisfaction, the idea seems still to prevail

*The Electrical World and Engineer, Volume XXXVIII, page 548 et seq.

in some minds that the design is such that it will not lend itself to the requirements imposed by the various engineering conditions of the present time. The article referred to was written with the object of dispelling this unnecessary fear, and to convince those interested that this type of alternator, when properly designed and constructed, will readily meet the most severe conditions encountered in the operation of generators of all sizes and types.

It briefly discusses the electrical and magnetic features of this type of alternator, describes the mechanical construction, and, perhaps of most importance to central station men, gives the characteristics and data of a few machines, among which are the 2000-kilowatt units of the Bay Counties Power Company, fully illustrating the actual operation under working conditions.

There are several mechanical and electrical details to be described which will be better understood and appreciated if the magnetic and electrical relation of the parts are first discussed. As in all other dynamo electric machines, the generation of the electromotive force depends upon the inductive action of a magnetic field upon conductors placed in armature slots, but the distinguishing features are the disposition of this magnetic field in a plane parallel to and passing through the axis of the rotating member, and that both the armature and field coils are placed on the stationary part of the machine. The revolving element, usually called the "inductor," consists of a steel mass of proper construction, the periphery containing polar projections which in sweeping past the armature windings induce therein an electromotive force. The exciting coil is usually a single stationary coil properly disposed with reference to the magnetic circuit. It follows that all the poles on one side of the machine are of the same polarity. Figure 1 represents a developed



THE HIGH TENSION SWITCHES ARE IN THE GALLERY ABOVE THE SWITCHBOARD.

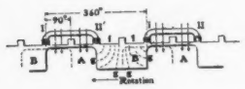
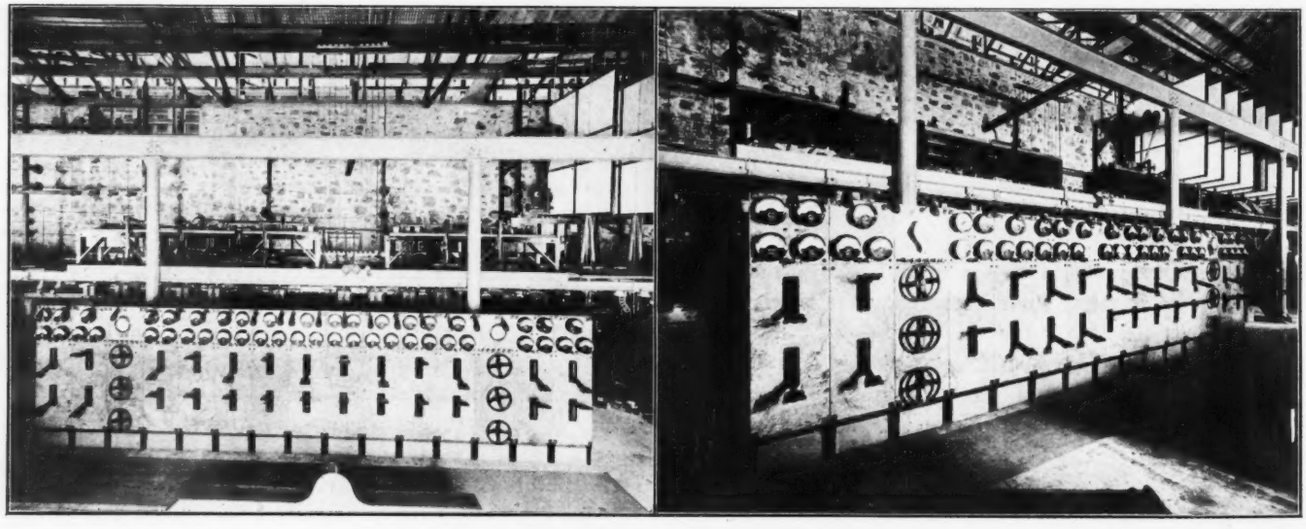


FIGURE 1.

portion of the armature surface with the corresponding poles. Let the direction of rotation and of the flux be as indicated by the arrows. The winding of one phase only is shown. With the poles in position *A*, no electromotive force will be induced in the winding. However, as they move toward the left, leg *I* of each coil is subjected to the action of the flux and generates an electromotive force directed perpendicular to the plane of the paper and downward, which rises to a maximum when the poles are in position *B*, and again falls to zero when the poles lie between legs *I* and *II'*, thus completing one-half of the cycle. The direction of the current is shown by the full



THREE VIEWS OF THE GENERATOR SWITCHBOARD AT COLGATE.

line arrows in figure 2. Leg *II* of each coil will now generate an electromotive force which, as before, will be directed perpendicularly to the plane of the paper and downward, and which will pass through a similar cycle. The broken line arrows in figure 2 now indicate the direction of the current. Obviously this direction is reversed, and the second half of the cycle thus completed.

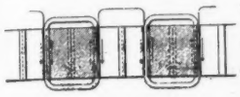
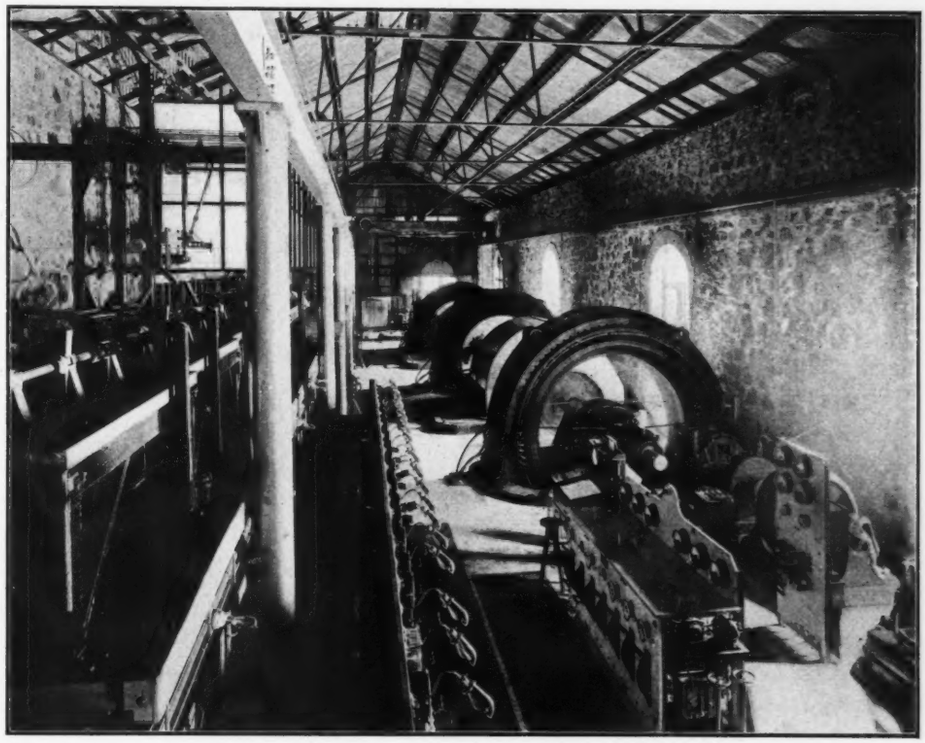


FIGURE 2.

If a second winding is placed in the slots midway between the winding shown, it will have induced in it an electromotive force differing in phase by 90 degrees from that in the first, and the whole will constitute a two-phase winding; similarly, with slots 60 degrees apart a three-phase winding is obtained.

The armature winding of an inductor alternator is usually of the style known as concentrated windings, that is, all the conductors per pole per phase are placed in a single slot. Since the instantaneous value of the electromotive force induced in such a coil is proportional to the strength of the magnetic field which it is cutting at that instant, it is apparent that with the pole shaped as shown in figure 2, and having an approximately uniform density over the entire pole face, the curve which represents the instantaneous values of the electromotive force throughout the cycle will not be a sine curve, but a flat topped curve, which comes to zero quite abruptly. An approximation to a sine curve may be obtained by distributing the winding in two or more slots per pole per phase, or by properly shaping the pole piece, so that the air gap density will vary in some definite way. Both of these methods will again be considered.



THE OPERATING TABLE OCCUPIES A CENTER POSITION IN THE COLGATE POWER HOUSE.

Since with a fixed impressed electromotive force the magnetic fluxes through two parallel paths are inversely proportional to their respective reluctances, it will at once appear that a field must exist between the polar projections as indicated in the lines *F G* in figure 1. This is the leakage field of the inductor alternator, and extends, as shown, from the armature surface between the poles to the iron parts beneath.

The field rotates with the main field, and therefore reacts on that portion of the winding not under the pole face, inducing an electromotive force opposed to that set up by the main field. Hence it is of importance to keep this field as small as possible. A method for accomplishing this will also be considered later.

As has been shown before, all the poles on one side of an inductor alternator have the same polarity, hence the armature teeth and iron are always magnetized in approximately the same direction. When the tooth is directly under a pole it is working at its maximum density. This decreases as the tooth emerges from under the pole, and becomes nearly zero when midway between the poles, increasing again to maximum when it is directly under the following pole, but always magnetized in the same direction. Likewise in the armature body, excepting that here there is a slight change in direction owing to a small angular swing of the flux. Hence the direction of magnetism is never completely reversed, as it is in other types of alternators, but merely increases from a zero to a maximum value and again decreases to zero with a nearly constant direction.

A thorough appreciation of this fact is necessary, for upon it depends, to a large extent, the economical design and good operation of inductor alternators. Since the iron is worked only through a partial cycle, the iron losses must be extremely small if worked at ordinary low densities, or it can be worked at very high densities without bringing the losses up to those found in other types. Also, since the magnetic flux follows a radial path through the iron to the magnet bars, the radial depth of the armature laminations is determined entirely by mechanical reasons. If the armature and winding are designed with this point in view, the radial depth of iron can be made much less than in revolving field alternators. Having but a single coil for excitation, the copper required is reduced to a minimum, and therefore the field ($C^2 R$) losses are small. Owing to the low iron and field losses, and the extremely good ventilation obtained with the style of inductor adopted, the armature losses can be taken

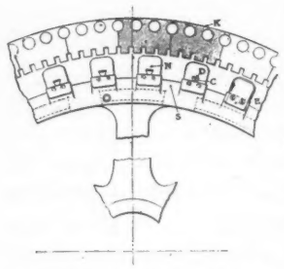


FIGURE 3. SECTION OF S. K. C. INDUCTOR ALTERNATOR.

high without loss in efficiency or excessive heating. It would at first appear that if only one-half of the winding is effective at a time, either the amount of copper or the amount of iron must be twice as great as in an alternator in which the whole winding is active. However, the above shows that this is not the case, and, as a matter of fact, the active material in a properly designed inductor alternator is but very little in excess of that in other types. Another fact of interest is that working the teeth at such high densities as are possible in inductor alternators results in a remarkable improvement in the regulation. This will again be considered later.

Enough has been said to show that the entire design tends toward a machine of good full load efficiencies, and owing to the low iron losses, one of very good efficiencies at partial loads. It will be shown later that the regulation can be made equally satisfactory.

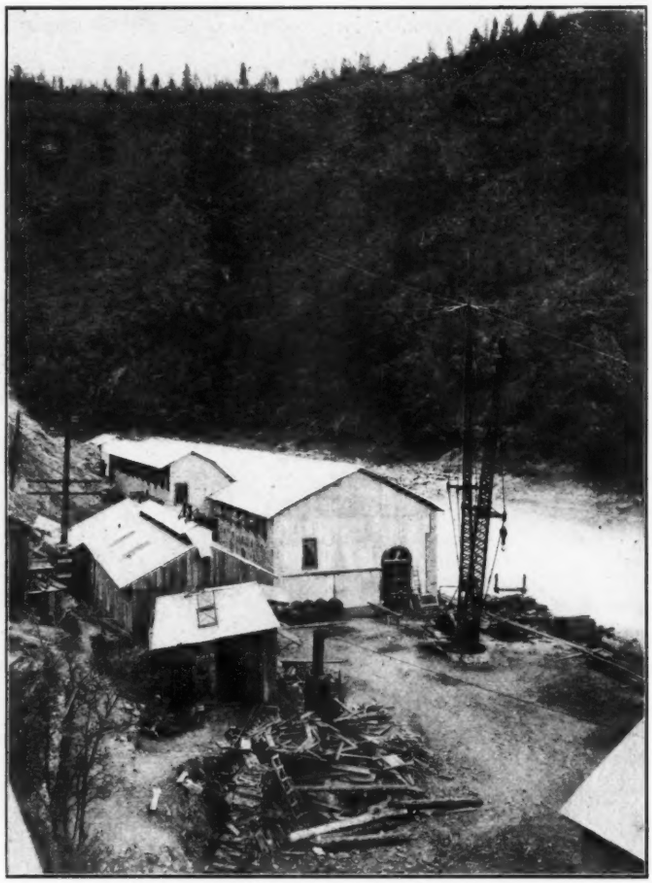
Figure 3 shows the section of an S. K. C.* alternator. The inductor consists of a cast steel spider and rim, *A*, made either in two parts for small generators or in four parts for large machines, these parts being securely and firmly bolted together to form a revolving element of rigid and safe construction. The hub is usually clamped to the shaft and held in place by either one or two keys.

On the face of the rim the lugs, *B*, are cast, for the purpose of holding the laminations, *N*, which form the pole pieces. The method of securing these laminations to the lugs can readily be seen. *C* is a key fastened to the lug by a number of screws. The laminations are slipped over the key, *C*, the slot, *D* (figure 4), fitting snugly onto the same, and the whole held in place by the retainer, *E* (figures 3 and 4).

The punchings, *N*, are always shaped so as to cause a distribution of flux across the pole face, such that the induced electromotive force wave will have the closest possible approximation to a sine curve. This is effected by varying the air gap gradually from a minimum at the center to a maximum at the outer edges, according to data determined theoretically and verified experimentally.

The entire construction is of the most rigid character, at the same time the fibre strains are taken low so the inductor will stand an increase of speed of 50 per cent. with perfect safety. This robust construction, together with the fact that the revolving part contains no wire or other active material liable to injury, permits of the use of high peripheral speeds, which is a distinct advantage in designing electrical machinery in many instances. Surface speeds as high as 10,000 feet per minute have been used in large high speed alternators.

The metal at *S*, between the pole pieces, is entirely cut away. The method of construction can more readily be seen and understood from some of the following cuts of generators. This results in greatly increasing the reluctance of the leakage path, and therefore decreasing the leakage field in proportion. The effect of this field is therefore hardly appreciable, the flux itself never amounting to more than 5 per cent. of the main flux. The construction of the armature is in every way as rigid and substantial as that of the inductor.



VIEW OF COLGATE POWER HOUSE, LIGHTNING ARRESTER HOUSE AND MACHINE SHOP.

The steel bars, *F*, are called magnet bars, and serve the purpose of carrying the magnetic flux. The inside rings, *G*, are first placed over them and held apart by the washer, *H*. The armature punchings, *K*, are then slipped over the bars and finally held in place by the outside rings, *L*. Heavy steel stiffeners, *M*, are placed at each end of the laminated iron.

It may be noted here that with the exception of the rings *G* and *L*, all the metal is active, that is, is utilized for carrying the flux. This type of alternator therefore requires no additional cast iron or steel structure to carry the armature iron, so with the reduction in the weight of the lamination made possible by the use of

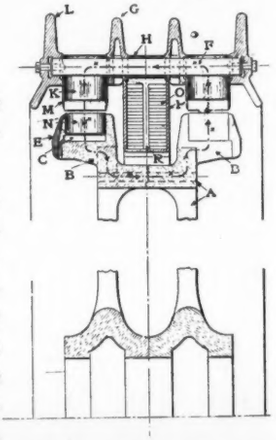


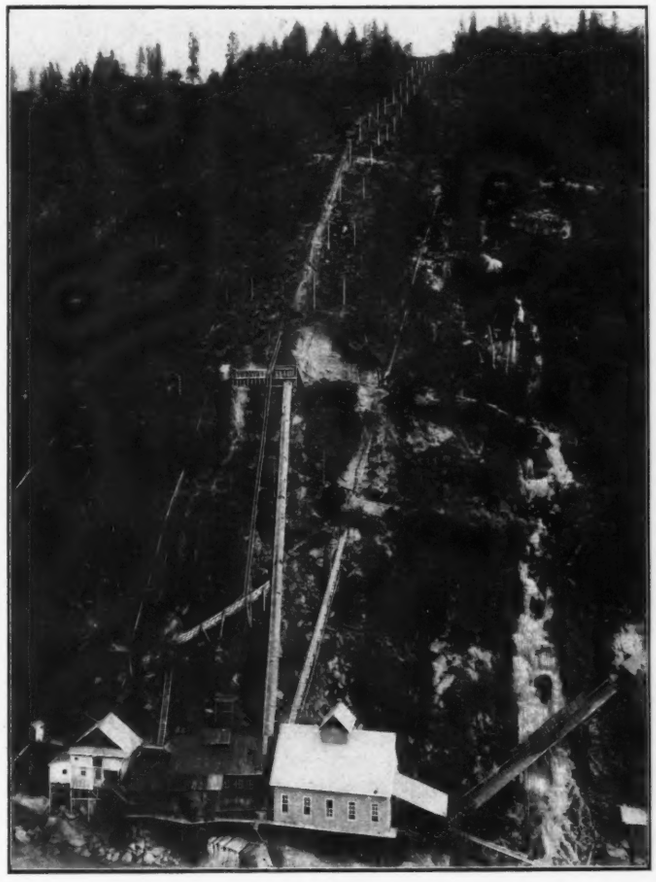
FIGURE 4. SECTIONS OF S. K. C. INDUCTOR ALTERNATOR.

*S. K. C. are the initials of the individual inventors of this type of apparatus —Messrs. William Stanley, John F. Kelley and C. C. Chesney.

high densities, as before explained, the weight of an inductor alternator will not be greatly in excess over the weight of a revolving field type having the same characteristics.

After assembling in the manner described, the coils which make up the armature windings are placed in the slots. The coils are machine wound. They are carefully and thoroughly treated with insulating compounds, wrapped with a special insulating material and baked before they are placed in the machine.

The winding is of the style generally known as a concentrated winding. Owing to the specially shaped pole pieces it becomes unnecessary to distribute the coils in this type of alternator to obtain a sine wave of electromotive force and all the advantages of a concentrated winding can be fully realized. It permits of the maximum insulation with minimum expenditure of room, ensuring perfectly reliable insulation for all voltages. When it is known that for some potentials about 40 per cent. of the slot is taken up with insulation, it will readily be seen what an important item this is in the economical design of alternators. It permits of readily removing a coil for repairs without disturbing a large number of other coils. In most machines of this type under discussion the coils can be dropped down between the pole-pieces and then drawn sideways, thus making it possible to remove a coil without disturbing any other part of the machine. Sliding armatures, therefore, are altogether unnecessary.



THE FIRST COMPREHENSIVE VIEW OF THE NEVADA COUNTY POWER HOUSE EVER TAKEN.

The claim is often made that owing to the concentrated winding the self-induction of the armature circuit must be extremely high, and that, therefore, the regulation of this type of alternator must be very poor on inductive loads. A consideration of the following facts will show that this claim does not hold good. When a current flows through the armature conductors, it sets up a field surrounding these conductors, varying with the current, and thus inducing an electromotive force in the armature winding known as the electromotive force of self-induction, or counter electromotive force. The field is directly proportional to the ampere turns in the slot and inversely proportional to the reluctance of the flux path. The counter electromotive force is directly proportional to this field and the number of turns. Hence, if the reluctance and current remain constant, the counter electromotive force will vary as the square of the turns per slot. For this reason it might at first appear that the above contention were true, and that distributing the windings in two or more slots per pole per phase, the self-induction must be greatly decreased.

As the number of slots is increased, the reluctance cannot be kept the same for the reason that will at once become apparent. For the sake of simplicity consider that the field set up by the armature ampere turns has two paths, one across the slot and the other around it. The reluctance of the path across the slot is inversely proportional to the depth and directly proportional to the width of the slot; in other words, this leakage field is much greater for a narrow and deep slot than for a wide and shallow one. For reasons given before, the slots in an inductor alternator can be made wide and shallow, the ratio of depth to width rarely exceeding 1.5, while with a distributed winding the slots must be made narrow and deep to accommodate the extra insulation required and to keep the machine from becoming excessive in size. In this type of machine the ratio of depth to width is usually three or more. The leakage around the slot is inversely proportional to the reluctance of this path. The fact that the teeth are worked at such high densities in inductor alternators makes the reluctance of this path very great. All this goes to show that the field which induces the counter electromotive force of self-induction is very little, if any, greater in an inductor alternator than in a revolving field alternator, as usually designed. If the ends of the coils lie in close proximity to the iron, as they usually do, there will be considerable self-induction in these parts. This can be reduced by splitting the coils, which is possible with a two-coil per slot winding, as is now used entirely for voltages up to 6000.

The slight reduction of the coefficient of self-induction due to distributing the winding is made manifest by the following: The coefficient of a machine having slots 1½ inches wide by $1\frac{5}{16}$ inches deep and 60 conductors per slot was measured and found to be .085 henries. New armature punchings were made and the 60 conductors

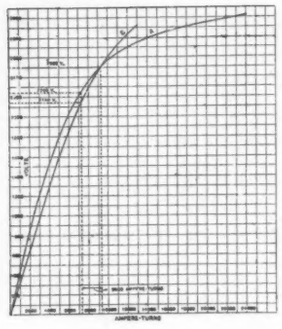


FIGURE 5. SATURATION CURVES.

distributed in three slots, each slot ½ inch by $1\frac{3}{32}$ inches. The coefficient was then found to be .076 henries, a reduction of 10 per cent.

Another important factor which causes a drop in voltage is armature reaction. To illustrate more easily the effect of this reaction, assume that there is no C R drop in the armature, and that the current is entirely wattless, that is, lagging 90 degrees behind the electromotive force. The counter electromotive force will then be in direct opposition to the induced electromotive force, and the armature ampere turns directly opposed to the field ampere turns.

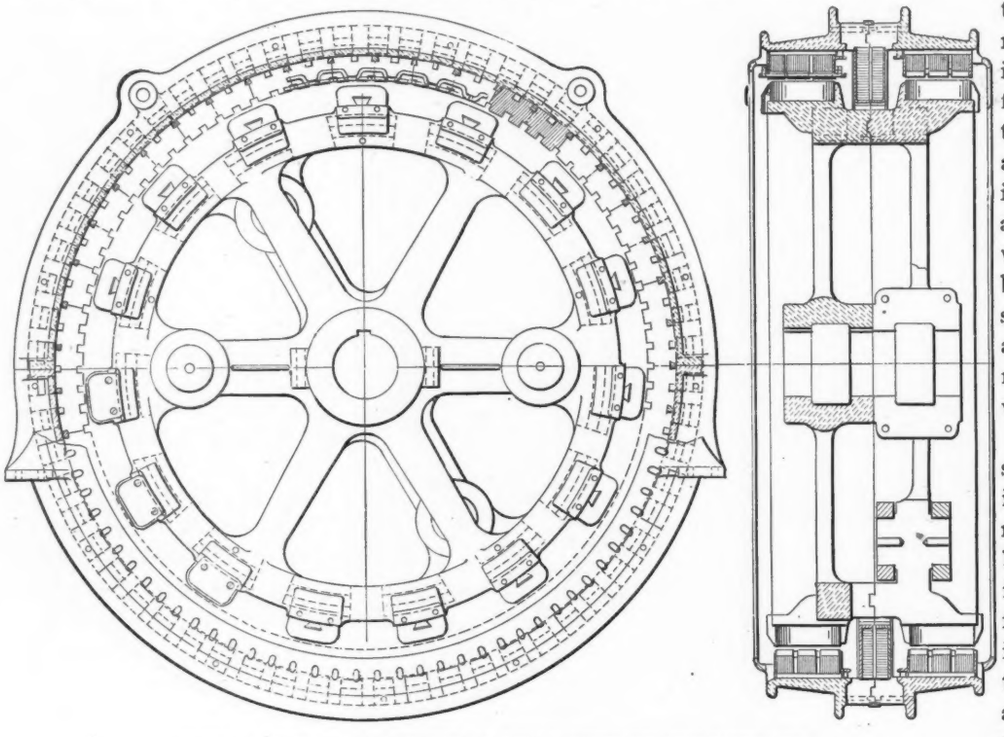


FIGURE 6. ELEVATION AND SECTION OF 2000-KILOWATT INDUCTOR ALTERNATOR.

Let *A* and *B* (figure 5) be two saturation curves. In *A* the machine is worked above the knee of the saturation curve and in *B* at the knee of the curve. The induced electromotive force is 2500 volts in both cases, and the armature ampere turns are 2000. The field ampere turns are 9300. Since with a wattless load the armature ampere turns are directly opposed to the field ampere turns, the resultant ampere turns will be 9300—2000=7300. These are equivalent to 2240 volts for *A* and 2140 volts for *B;* that is, the drop in voltage due to armature reaction is greater by 100 volts for the machine worked at the lower point. Assuming the counter electromotive force to be 100 volts for both machines, the total drop will be 360 volts, or 14.4 per cent., for *A* and 460 volts, or 18.4 per cent., for *B;* that is, working generators well above the knee of the saturation curve effects a marked improvement in their regulation, and especially for inductive loads.

For reasons given before, the armature teeth can be saturated, the core worked at very high densities, and, owing to the very short magnetic circuit, all other parts of this machine can be worked at high densities without unduly increasing the energy required for excitation. The inductor alternator, therefore, not only regulates well on non-inductive loads, but also regulates remarkably well on inductive loads.

The field coil, shown at *O* (figure 4), is made up of a wire or strip winding enclosed on three sides by a heavy brass bobbin, *P*. A ventilating space, *R*, is left in the middle, separating the winding into two parts. Air is forced through this space, as well as around the sides of the bobbin, by the poles of the revolving inductor. The winding is thoroughly insulated from the brass bobbin, while the latter, due to its secondary action, when the field circuit is broken, insures the coil from all danger of breaking down when discharged. Having but a single coil amply designed, thoroughly ventilated and stationary, the risk of this member becoming disabled is very slight indeed.

Sometimes, in large high speed generators, it becomes impossible, for mechanical reasons, to use the "magnet bar" construction. The type illustrated on page 69 and in figure 7 is resorted to. The inductor does not differ from that described before. For the armature, a cast steel ring, as shown, takes the place of the magnet bars and end rings, while the punchings are held in place by means of dovetails and keys similar to those described for securing the pole punchings. In all other respects this type corresponds with that previously discussed. Figure 7 illustrates the principles of the 2000-kilowatt, 240 revolutions per minute, generator of this type built for direct connection to a Risdon water wheel, and as used at the Colgate power house.

TRANSFORMERS.

While the same general features must be considered in selecting transformers as in selecting generators, and the question of regulation still remains an important factor in connection with transmission systems, the question of proper insulation undoubtedly becomes the one

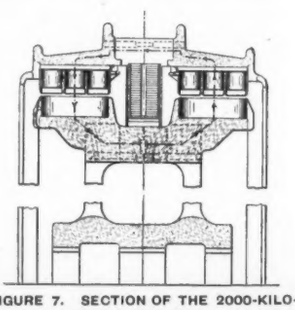


FIGURE 7. SECTION OF THE 2000-KILOWATT GENERATOR.

of greatest importance. Fortunately, in designing transformers to overcome the difficulties inherent to insulating for extreme potentials, the other features, such as regulation, heating, etc., are directly benefited. Since the life of the insulation depends largely upon the temperature to which it is subjected, the method of dissipating the heat due to the copper and iron losses thus becomes second in importance.

In considering the losses, due regard should be paid not only to those that will occur under normal conditions, but also to those that will occur under abnormal conditions, for instance, such as may be caused by periods of heavy overloads, repeated short circuits, or a failure in the auxiliary cooling apparatus. Any of these things may occur, and still the transformer should remain in service uninjured.

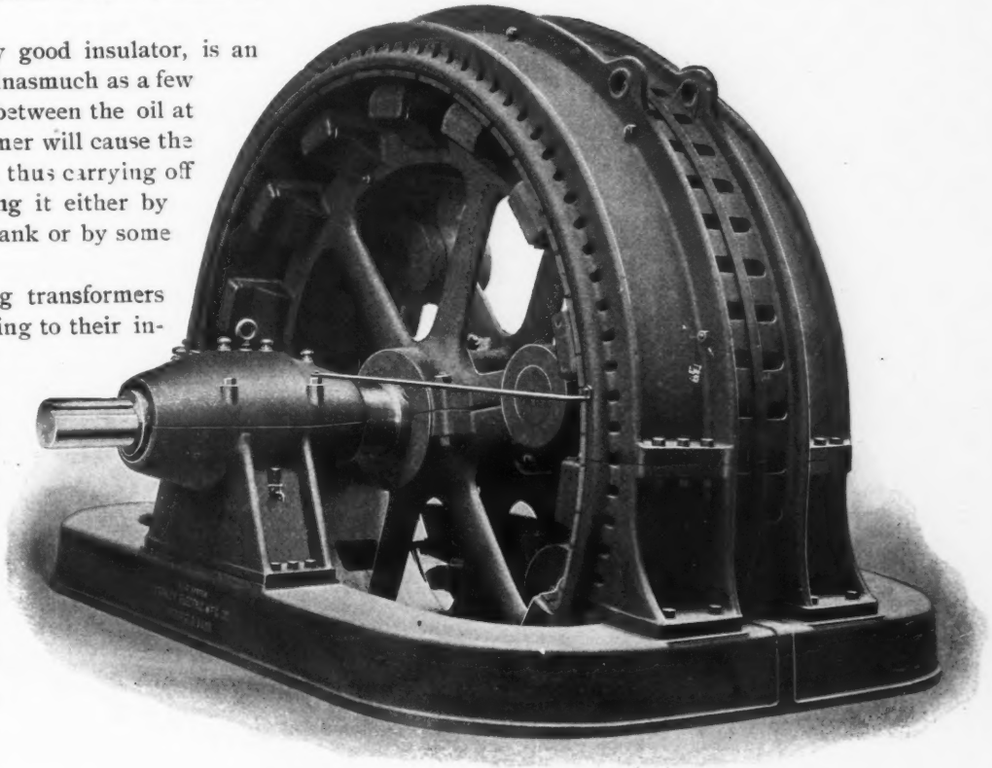
Oil, besides being a remarkably good insulator, is an extremely efficient cooling agent, inasmuch as a few degrees difference in temperature between the oil at the center and top of the transformer will cause the oil to circulate between the coils, thus carrying off the heat generated and dissipating it either by radiation from the surface of the tank or by some artificial means.

But for the fact that self-cooling transformers are impractical for large units, owing to their increased cost, a self-cooling, oil insulated type could be adopted. It therefore becomes necessary to select a type which is artificially cooled, either by air blast or by water.

Since for high voltages it is desirable to retain the good insulating qualities of the oil, the air blast method cannot be employed, and a water cooled, oil insulated transformer should be adopted for large units. Besides, where the motive power is derived from water, the installation and maintenance of the cooling appliances, consisting of supply and drainage piping, is extremely cheap, while the amount of water used is extremely small. Moreover, an increased water supply will permit of carrying heavy overloads for an extended time without injury to the installation. Again, as pointed out before, the oil itself is a good cooling agent, thus making it possible to run this type of transformer for a considerable period without the use of artificial cooling should the water supply fail.

The design must permit of a free circulation of the oil, at the same time insuring a perfectly rigid mechanical construction which will withstand the rough handling that is liable to occur in transit over railways and difficult roads, especially in mountainous districts.

An oil insulated water cooled transformer, besides possessing all the essential features, has the additional advantage of lowest cost per kilowatt output and per



PERSPECTIVE VIEW OF 2000-KILOWATT INDUCTOR ALTERNATOR MANUFACTURED BY THE STANLEY ELECTRIC COMPANY FOR THE BAY COUNTIES POWER COMPANY.

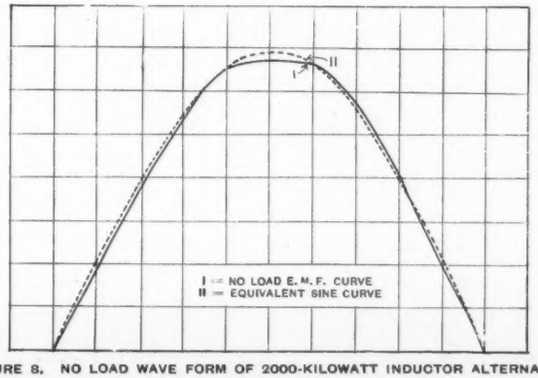


FIGURE 8. NO LOAD WAVE FORM OF 2000-KILOWATT INDUCTOR ALTERNATOR.

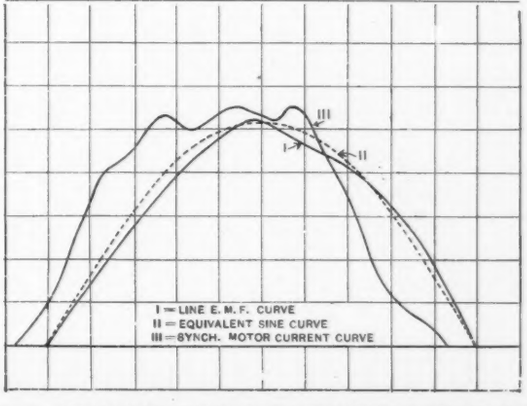


FIGURE 9. OSCILLOGRAPH CURVES OF ELECTROMOTIVE FORCE AND CURRENT TAKEN AT OAKLAND, CAL., 143 MILES FROM POWER STATION.

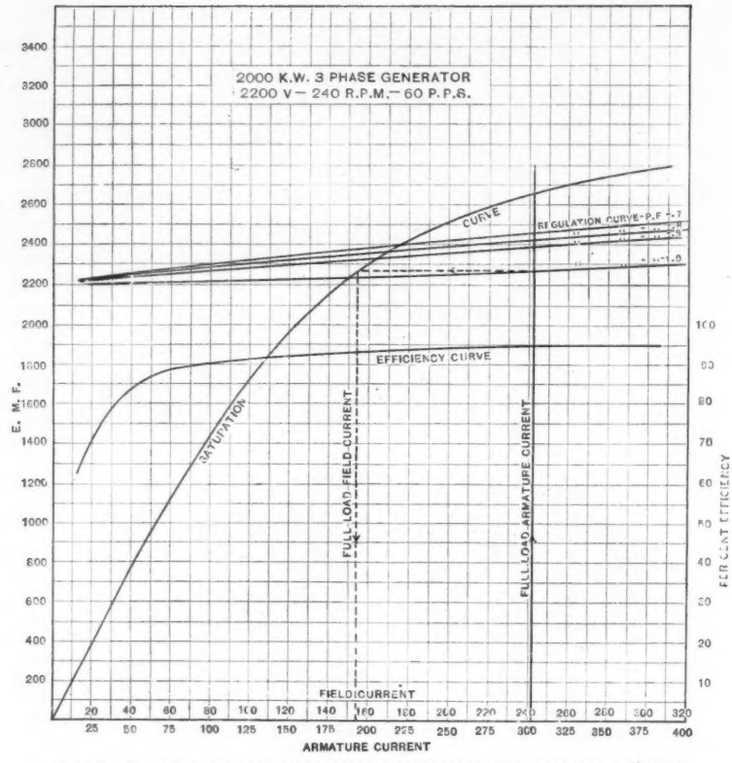


FIGURE 10. CURVES SHOWING ELECTRICAL CHARACTERISTICS OG 2000-KILOWATT INDUCTOR ALTERNATOR.

kilowatt installed, making by far the most desirable type for high tension long distance transmission systems.

The following description of the 700-kilowatt 60 periods per second transformers, built by the Stanley Electric Manufacturing Company and installed at the Colgate power house of the Bay Counties Power Company, will fully illustrate the many advantages of this type of transformer.

These transformers at present step-up from a generator pressure of 2300 volts to a line pressure of 40,000 volts. They are, however, designed for an ultimate line pressure of 60,000 volts, with taps brought out for 40,000 and 50,000 volts. The transformers themselves are wound on the low tension side for 2300 volts, and on the high tension side for 34,675 volts, with taps brought out for 28,925 volts and 23,175 volts.

Each unit consists of a group of three transformers, as shown in figure 11, with delta connection on the low tension side and star connection on the high tension side. The neutrals of each group are connected on the high tension side to a common ground, thus keeping the insulation strain within the limit of 35,000 volts.

Figure 12 shows a cross-section of the transformer, the iron being built up so as to form a complete shell around the coils, and the construction being known as the shell type.

With such high potentials it is necessary to adopt a large number of coils in order to reduce the electromotive force per coil. As shown, the high voltage winding is divided into 16 coils, thus reducing the maximum pressure per coil to 2167 volts. Each coil consists of 73½ turns of strip copper wound with one turn per layer. The potential between adjacent layers is very low and the layers are separated by heavy insulation, securing perfect reliability from internal short circuits. The coils are assembled in groups of two, being separated by micanite slabs which extend above the strip, as shown, to prevent arching between coils due to the existing difference of potential, insulation being filled in to bring the coils to a level with the micanite so that they may be readily taped together and insulated, thus forming one main coil. All the coils are connected in series, as shown in figure 13.

The low voltage winding is subdivided into eight coils. Each coil consists of 19½ turns of strip copper wound with one turn per layer, each turn consisting of three conductors in parallel. The coils are insulated and grouped in a similar manner to the secondary coils and connected, as shown in figure 13.

With such a subdivision of the coils as above described they can be made deep and narrow, thus insuring good radiation and low individual heating. With a few turns per coil the leakage field surrounding the coil is small; thus the electromotive force of self-induction of each individual coil is low and the regulation of the transformer is therefore vastly improved, especially on inductive loads. Also, with a low leakage field and the narrow laminated strip used, practically all the foucault or eddy currents are eliminated in the copper.

The high and low tension groups are sandwiched, as shown, and are supported and held in place on the core by means of wood blocks and wedges. As is well understood, this thorough interleaving of the coils is necessary to obtain a proper interlinking of the magnetic flux with all windings. The groups are separated by mica slabs and spacing blocks, the slabs projecting beyond the coils to prevent arching, and the construction being such as to permit of a free circulation of the oil between the coils. The material employed for insulating and supporting the coils from the core consists entirely of kiln dried wood and mica, both absolutely indistructible at any temperature

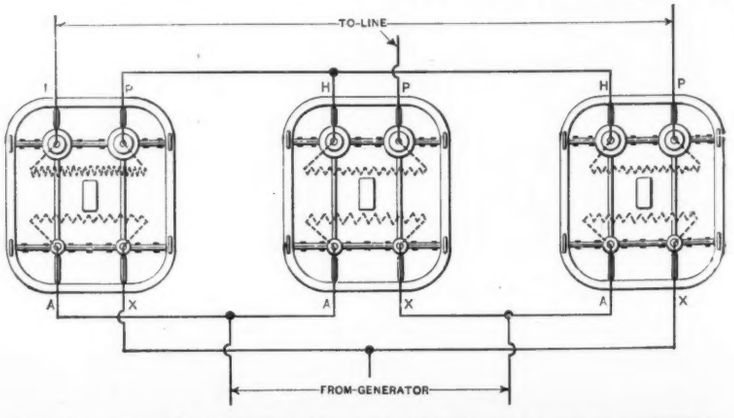


FIGURE 11. DIAGRAM ILLUSTRATING CONNECTIONS OF GROUP OF THREE TRANSFORMERS IN COLGATE STATION, BAY COUNTIES POWER COMPANY.

possible in these transformers under the worst conditions. The transformer is entirely supported by the cast-iron base and has no connection whatever with the sides of the case.

The main leads are brought up to wooden terminal boards, rigidly supported above the coils, these also having no connection with the case. Thus the design is thoroughly rigid and substantial, while at the same time the transformer may be removed from its case for inspection with the least expenditure of labor.

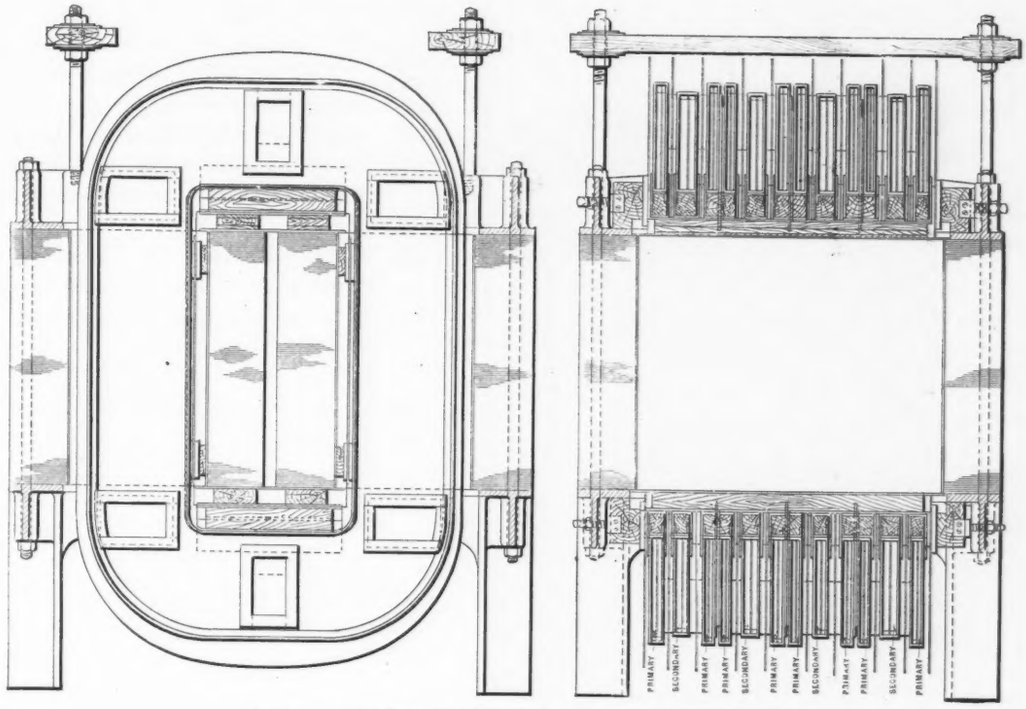


FIGURE 12. SECTIONAL ELEVATIONS OF 700-KILOWATT TRANSFORMER.

The cooling appliance, consisting of a few turns of brass pipe, as shown in figure 14, is supported from the sides in the upper part of the case. Through this pipe there is constant flow of cool water, varying from one and one-half to two gallons per minute according to the load. The oil as it circulates up between

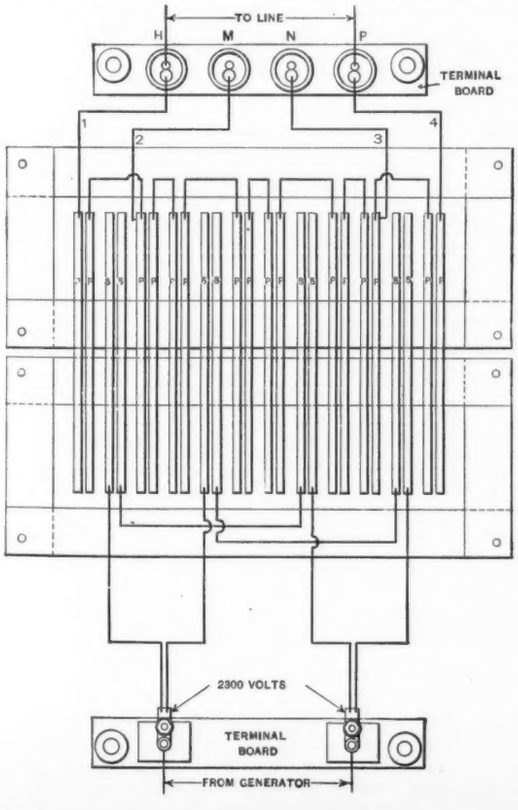


FIGURE 13. DIAGRAM ILLUSTRATING CONNECTIONS OF WINDINGS IN TRANSFORMERS.

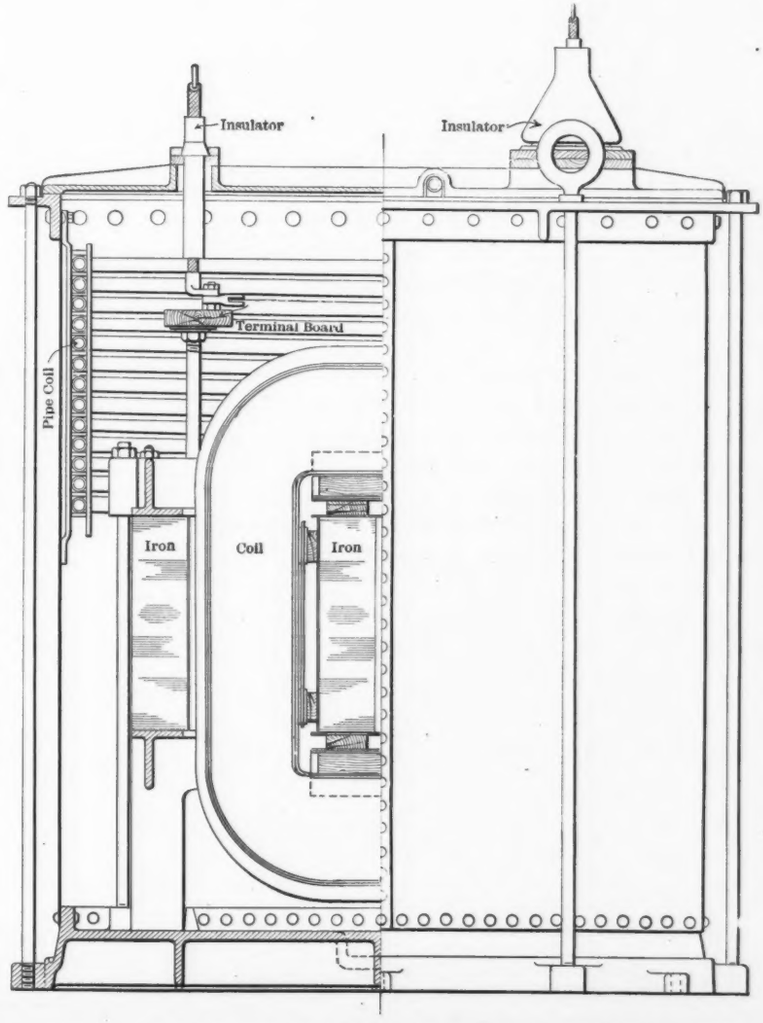


FIGURE 14. HALF ELEVATION AND HALF VERTICAL SECTION OF TRANSFORMER, SHOWING COOLING APPARATUS.

PERSPECTIVE VIEW OF TRANSFORMER.

the coils, conducts the heat to the cool surface of the pipe coil, transmitting it to the water which carries it off. As stated before, the circulation of oil is automatic, being due to the difference in temperature of the oil at the center and surface.

The leads from the terminal boards for connection to the line are brought out through the cover in heavy porcelain insulators, the high voltage ones being specially designed with a large surface to prevent all possible leakage to the case.

All the iron parts of the transformer are earthed, the core being grounded to the base through the iron legs which support the transformer, and the base itself being thoroughly grounded, removing every possibility of accident to the attendant.

Figure 15 gives some of the main electrical characteristics for this transformer, calculated from data obtained from shop tests.

The efficiencies given below are remarkably good at all loads. They are:

98.6	per cent.	at	125	per cent.	load.
98.5	"	"	100	"	"
98.4	"	"	75	"	"
97.8	"	"	50	"	"
96.2	"	"	25	"	"

That the transformer more than meets all regulation requirements is shown by the following:

At full load and 100 per cent. power factor, regulation is .7 per cent.

At full load and 90 per cent. power factor, regulution is 1.9 per cent.

At full load and 80 per cent. power factor, regulation is 2.4 per cent.

At full load and 70 per cent. power factor, regulation is 2.6 per cent.

The rise in temperature of the oil after full load run of twenty-four hours did not exceed 35 degrees centigrade above the air, while the transformer will carry 25 per cent. overload with a rise of 45 degrees centigrade, besides carrying larger overloads without dangerous heating.

The insulation tests given to the transformer were as follows:

Seventy-five thousand volts between high tension winding and iron for one minute.

Seventy-five thousand volts between high tension winding and low tension winding for one minute.

Thirty-seven thousand volts between low tension winding and iron for one minute.

BUILDING THE DAM AT LAKE FRANCES.

Some of the old time operations of the miners for placer gold and the use of the hydraulic "giant" have suggested an ingenious method of constructing dams for reservoirs in the West. The hydraulic giant was found to be a most effective and powerful agent in removing even compact bodies of earthen material. A stream of water brought from an elevation under great pressure and directed against the face of a hill in which gold was supposed to be tore its way into the mass with tremendous force, cutting out large amounts of the material and washing them away, the waste water assorting the fine from the coarse particles. The sand and gravel thus washed away was carefully examined for the precious metal.

Of recent years hydraulic power has been employed to almost reverse this process. Engineers, appreciating the great transporting and assorting power of water used in this way, have availed themselves of it to build up instead of tear down the land; and by carefully guiding the material loosened by the force of the water they have been able to accumulate and arrange it almost at will. The process has been found especially useful in the construction of dams. For example, if an earth dam is to be built, the

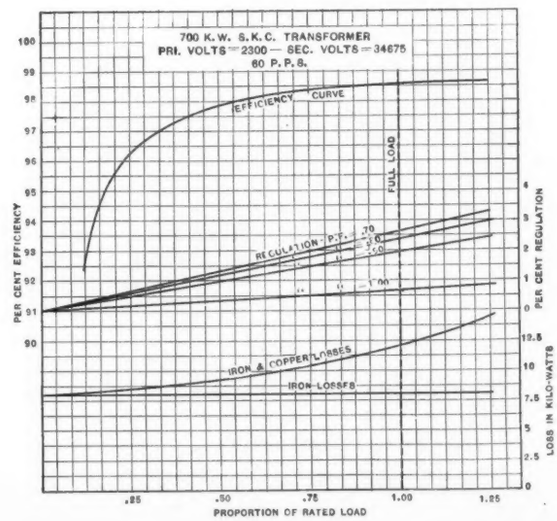


FIGURE 15. CURVES SHOWING ELECTRICAL CHARACTERISTICS OF 700-KILOWATT TRANSFORMER.

material rolled along by the water is carried in flumes to the selected spot. On leaving the flume small boulders and coarse gravel are at once deposited. The sand flows on farther, and the fine mud is carried in suspension for considerable distances. It is thus possible to deposite the gravel on the outer slope of the dam and the finer material in the center, thus making a central impervious clay wall and heavy coating of coarser gravel on the upper and lower faces on the dam. The material being deposited under water is thoroughly compacted, and there is less danger of settlement or of porous layers being formed than in the case of dirt placed by carts or scrapers. A number of dams, notably in southern California and in Texas, have been built with extraordinary speed and small expense in this way, and even high railroad embankments have been constructed in like manner.

In central California the most noteworthy instance of hydraulic dam building which exists is afforded in the work at present under way by the Bay Counties Power Company at Lake Frances, a few miles above the Colgate power house. The progress of the work is admirably shown in the three half-tone illustrations appearing on pages 60, 61 and 62 of this issue.

Lake Frances, which has a storage capacity of nearly 93,000,000 cubic feet of water, is essentially an emergency reservoir, as it is to be drawn upon only in case of accident to the main flume supplying the power house at Colgate. The altitude of Lake Frances above the main flume is 382 feet, the lake being filled by Dobbin's Creek. When the supply of the lake is drawn upon, water is carried thence through a pipe line and rapid flume for a distance of two miles, as described heretofore,* and delivered into the penstock supplying the five pipe lines leading to the power house. Water for the operation of the hydraulic giants used in building the Lake Frances dam is taken from Dobbin's Creek, and the procedure seems to be so fully portrayed in the illustrations given that further description appears redundant. It is interesting to note, however, that this method of construction of dams is being made the subject of study by the Division of Hydrography of the United States Geographical Survey in connection with investigations as to the feasibility of reclaming the arid lands of the West.

A SUGGESTION IN INCLINED PIPE LINES.*

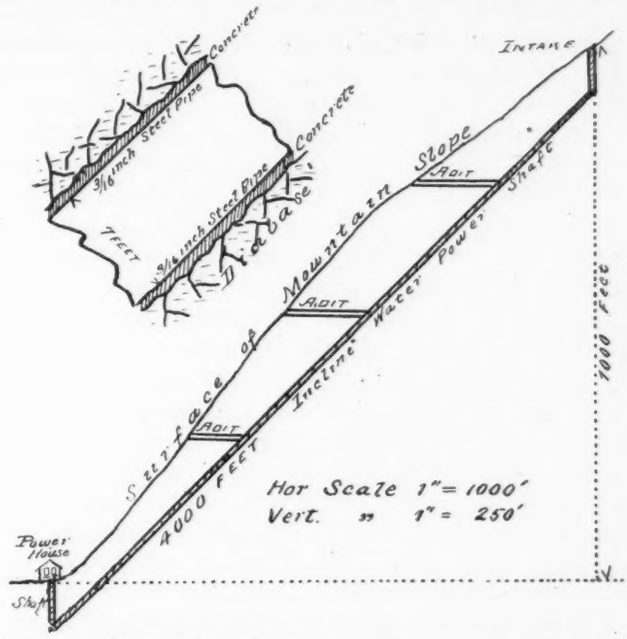
BY LUTHER WAGONER, M. E.

THE topography of the Sierra Nevada mountains in California has made possible the use of water for power development under extremely high heads. In one instance a water pressure from 1400 feet of head is being employed, and a plant to use 1700 feet head has been projected.

Where the quantity of water used is comparatively small, the construction problems have presented no special difficulties; but the increasing use of very large volumes of water under very high heads has made the cost of installation of the water power plant a matter requiring much more consideration than with the smaller plants.

The writer, associated with Mr. J. R. Price, C. E., was lately called on to plan the construction of a large power plant, utilizing the water of the North Yuba River, in Yuba County, Cal. The plans provided for the utilization of 315 second feet of water with a drop of 1000 feet from the intake to the water wheels in a distance of 4000 feet. A single pipe to carry this quantity of water would have to be 7 feet in diameter and it would require a thickness of metal at the lower end of 1½ inches, which is not practicable. The method generally used in California under such conditions would be to divide the water among a number of pipes so as to reduce the thickness of the metal. Assuming ⅞-inch as the limit of thickness for riveted work, and taking the working strain for the iron at 12,000 pounds, there would be required to carry the water three pipes of 48 inches diameter. The metal for the three pipes would weigh about 2100 tons, which would cost in place about $240,000, exclusive of the drum and branch pipes to the wheels in the power house. To avoid this heavy cost and insure a safer construction and a saving of 1.2 per cent. of the power from loss as extra friction in the three pipes over what it would be in one, we devised the following plan of construction:

The country rock along the slopes from the intake to the power house is a firm, massive diabase, and it is only a short distance from the surface to solid rock. At the power house it would be proposed to excavate down to the solid rock for a foundation and to sink a circular shaft, say 100 feet deep, in the rock. From the



bottom of this a drift would be run each way under the power house. Also, there would be run an inclined upraise about 8 feet in diameter parallel to the surface of the hill slope a distance of 4000 feet to the intake end of the conduit at the head box on the canal. This upraise would be constructed through several short adits from the hill slope, which would later be closed with concrete next to the upraise. The upraise would be lined with a sheet steel lining $\frac{3}{16}$-inch thick, made in 6-foot lengths, to slip-joint in place after being well dipped in asphaltum. The space between the outside of the pipe and the wall of the rock would be well rammed with concrete. The purpose of the light pipe is to prevent leakage. Reliance is had on the solid rock and the concrete filling for strength to resist the static pressure.

Under the power house a similar construction of thin metal pipes in concrete backing to the solid rock will divide the main into three vertical 48-inch pipes, which will rise about 50 feet from the short drifts described above, and then branch into two 30-inch diameter, lapwelded and flanged pipes, which will enter the power house through the floor and deliver water to the wheels.

The plan would provide a construction which the accompanying sketch will illustrate. It would seem to eliminate the possibility of accident to the water conduit line. The cost of this work complete we have estimated at about $126,000, as against $280,000 for three 4-foot pipe lines laid on the surface in the usual manner.

*From the *Mining and Scientific Press*, Volume LXXXIII, page 270, December 21, 1901.

THE JOURNAL OF
ELECTRICITY, POWER AND GAS

Devoted to the Conversion, Transmission, and Distribution of Energy.

CONDUCTED BY GEO. P. LOW.

Official Organ of the Pacific Coast Electric Transmission Association.

Published monthly. Yearly subscription: Domestic, $1.00; Foreign, $1.50.
Subscriptions can not be begun with back numbers.
The price of single copies is variable.

Entered as second-class matter at the San Francisco Post Office, August 15, 1899.
Entered as *The Electrical Journal*, July, 1895. Entry changed to *The Journal of Electricity*, September, 1895.

PUBLICATION OFFICE:
144 Union Square Avenue ('Phone Bush 519), San Francisco, Cal.
Address remittances and communications to
315 CHERRY STREET, [Telephone, "Pine 76"] SAN FRANCISCO, CAL.

VOLUME XII APRIL, 1902 NUMBER 4

EDITORIAL.

SOME NATURAL CAUSES.

The incentives that have spurred men on to do great things in the Far West have become oft-told tales, especially in so far as gold seeking is concerned. So, too, do we weary of the stories that have been related attributing the wonderful development of transmission engineering to the high-priced fuel and the favorable climate of California. The fact that the highest attainments in the transmission of power by electricity have been reached in California is patent and speaks for itself, yet by no means all engineers of even America know it, or, knowing it, but a very meagre few appreciate the reasons of its being. In truth, we come to believe that the world knows but little of the Pacific slope of the American Union, and even the engineering world, so generally discerning, too often regards it with the clouded perception of ignorance.

Let us, then, take any given locality—Tulare County, in California, for instance, will do as well as any other. In it the Mount Whitney Power Company ever prospers and grows in the business of wresting energy from a mountain stream, and, through the beneficence of electric transmission, delivering it to orchard and fallow, and, mayhap, to every industry. Let us take this community, albeit small, and trace its history from its, to us, beginning, now barely over half a century ago. Let us learn of its settlement, its productiveness, its topography—in brief, of its marvels—and so let us come into a clearer understanding of that high plane of civilization into which this erstwhile wild and woolly Western country of ours has developed.

About December 1, 1850, a little band of fifteen men, under the leadership of a man named Woods, with saddles and pack animals, some arms, and implements for building, located on the south bank of the Kaweah River, seven miles east of the present city of Visalia. A few miles to the east of this point, in the foothills of the Sierra Nevada Mountains, there dwelt a tribe of Indians noted at that day for their savage hostility to the settlers along the coast, upon whom they had made frequent raids, driving to their homes such cattle and horses as they could steal. Some of these Indians had lived at the missions and ranches along the coast and could speak the Spanish language sufficiently to make themselves understood.

With the characteristic hardihood of the American pioneer, and doubtless lured by the wonderful fertility of the soil and beauty of the oak groves along the Kaweah, which from the days of Fremont to the present time have excited the wonder and admiration of all, Woods and his sturdy little band braved the danger of massacre for the sake of a new land which excelled in fertility anything they had ever seen. It was not mines that drew them like a magnet to their fate in a day and time when mining was practically the only industry of a golden west, for no gold had been discovered on or near the Kaweah. It was the native fertility of a land watered by this stream and its three branches which in those early times made this locality famous throughout the valley.

The winter of 1850–51 being mild and pleasant, as winters always are in that vicinity, these men progressed well with their improvements. They constructed a substantial log house, cutting oak trees for the purpose, splitting oak logs for the roof and hewing timbers for the rafters and doors. But toward spring the peace of their dreams was rudely disturbed by an Indian named Francisco appearing at their little settlement with a number of his braves, and, in broken Spanish, notifying the settlers to leave that section of the country within ten days on pain of death. They agreed to go, but evidently with reluctance and with the intention of soon returning, as they buried their provisions and such farming implements as they possessed. They then proceeded to gather their stock. While thus engaged the tenth day passed and the Indians returned to fulfill their threat. Ten of the party were killed while hunting stock. Two made their escape, one of whom was wounded. The savages then approached the house where were Woods and another. They professed friendship, and thus removed the apprehension of their victims, unconscious of the fate of their fellows. One of the whites was asked to hold up a target that the Indians might display their skill with the bow and arrow, and complying with this was shot to death by the treacherous redskins. Woods fled to the cabin and fastened the door and defended his life bravely, killing seven of his adversaries before his supply of ammunition gave out, leaving him in the power of the cruel savages, who, when they found that he was without further means of defense, broke into the cabin, captured, bound and tied him to a tree, and, while defying his torturers, his skin was taken from his body. The facts as to the fate of Woods and his companions were afterward gleaned from the Indians themselves, who were never punished, though many of them, including Francisco, the leader, lived for several years thereafter in that locality.

Thus was Tulare County baptized in blood. Thus did the first settlers of our great Kaweah delta risk all and lose all in the attempt to turn to man's benefit the wonderfully fertile soil, the beauteous groves of stately oaks and the salubrious climate of what has since justified their choice by proving to be a veritable garden spot in the richest valley of the world.

About a year after this tragedy Tulare County was created, and the spot where Woods so bravely died established as the seat of justice, under the name of Woodsville, from which point it was soon removed to Visalia, the present county seat.

The old times and all but very few of the old settlers have gone. The energy and nerve that was once expended in subduing the wild Indian and overcoming the natural lawlessness of the pioneer times is now expended in the development of these natural resources which attracted Woods and his band from the mines of Mariposa to the pastures and groves of Tulare. The wild Indian has vanished. Peace and prosperity now fill the soul of man with an ambition for still greater advancement. Here in the center of the delta of the Kaweah our city has grown and prospered greatly. The soil of this delta was formed by the alluvial wash of the streams. Before the coming of white men, while these streams ran at will, they filled up old channels and made new ones, and at intervals of high water flooded the country. There was thus ever a renewal and renovation of the soil that caused its wonderful fertility and adapted it to the production of deciduous fruits, alfalfa and other forage plants, and of vegetables.

A prosperous and tributary country laid broad and deep the substantial business foundation of the little settlement of nearly fifty years ago which has now developed into the growing, energetic and thrifty community known to the world as Tulare County, California, and containing as its principal center the prosperous city of Visalia. In early history Visalia was the only interior town between Los Angeles, 250 miles to the south, and Stockton, 150 miles north. There are hundreds of cities, towns and villages between these points now, but Visalia remains one of the best and most prosperous. Stockmen in time gave place to farmers, and grainfields waved where untended flocks and herds formerly fed and fattened, and railroads were built to carry away the millions of bushels of wheat annually harvested.

Then came the fruit grower to make the land more productive, and now Visalia is surrounded by thousands of acres of prolific orchards, the products of which, green, dried and canned, are transported to distant markets during the fruit season in train load lots daily. In the surrounding country grain is still produced largely and stock raising is an important industry, but all kinds of stock are highly bred and pastured in green fields of alfalfa, which alternate with orchards and farms for miles on every side. It is such a productive surrounding territory, every acre of which may be made to yield profitable returns, that has made Visalia a thrifty business center, and assures the permanence of its future as such. It is the county seat of the rich county of Tulare, which comprises a wide section of the western slope of the Sierra Nevada and of the level San Joaquin valley or plain, and has an area of 4935 square miles. It is an incorporated city of 3500 inhabitants, orderly, and with a good municipal government. The business streets are paved with asphalt and the graded sidewalks of the greater part of the municipality are wide and clean, and in the residence portion lined with shade trees of many varieties. The streets are well lighted, as are business houses and residences, by electricity.

Many years ago, when horticulture in California was in its infancy, when prices of all kinds of fruits were extremely high, and when to the fortunate owners of the first deciduous orchards to come into bearing was pouring in an unprecedented harvest of wealth, a stimulus was given to the industry that caused the wholesale and indiscriminate planting of fruit trees of all kinds throughout the State. The particular requirements of different varieties in the way of climate and soil were unknown, and many unsuccessful and costly experiments were made. Time and experience have demonstrated the fact that the locality adapted for the cherry or the walnut may not do at all for the prune or the pear; that, in short, each variety requires special conditions in order to realize its highest possibilities of growth, yield and quality.

The era of experiment has now passed. The fabulous returns of former years are no more. The fruit industry has gravitated until it is upon a strict business basis. The orchard in the wrong place does not pay; but, on the other hand, that the orchard in the right place does pay, and pay extremely well, and will continue to do so is now a known certainty. Formerly, when it was supposed that fruit of any kind would grow to perfection anywhere in California there was the fear of over production. Now that it is known that the localities especially and particularly adapted to the different varieties of fruit are limited in area, prices have reached a stable equilibrium, competition from unfavored localities is not to be feared, and over production no longer threatens.

Experience has shown that the Kaweah delta in the vicinity of Visalia is especially adapted to the production of certain deciduous fruits, and that the production of those fruits in this vicinity has been very remunerative. The soil is, of course, an alluvial loam, very friable, of great depth. Except in a few sinks the strong alkaline elements of the soil have been washed to lower levels, leaving, however, a soil rich in nitrates and in potash, an element upon which deciduous fruit trees largely draw. Coupled with the natural perfect conditions for tree growth of soil and moisture, the climatic conditions are so extremely favorable by reason of the warm early spring, summer nights not too cool to check growth, and a late fall, that trees have the advantage of a longer growing season than in almost any other section of the State.

And as to scenery, the highest mountains, the deepest canyons, the largest trees, and the finest trout streams in

the nation are in the Sierra Nevada Mountains just back of Visalia. This sounds boastful, but one moment will convince. Mt. Whitney, over 15,000 feet high, is located in Tulare County. Look at the atlas and see if Mt. Whitney is not the highest mountain in these United States, excepting outlying territories. Now about the deepest canyons. The greatest view in Yosemite Valley is obtained from Glacier Point, where one can stand and look down into the valley below for 3200 feet. Just come with the writer to Whitney and look down from its summit to Lone Pine. It is so far that you can distinguish nothing with the naked eye, but take a glass and you can trace the line of trees and see something that may be houses. It is 11,000 feet down to Lone Pine. Is there a place on earth that can duplicate such a scene?

Regarding the largest trees, Giant Forest lies fifty-seven miles east of Visalia, and is reached by stage line from Visalia direct to the forest over a road built with money appropriated by Congress for that purpose. This congregation of giants occupies an area of three miles square on an elevated plateau east of the Marble Fork of the Kaweah River. It is estimated to contain more than three thousand sequoias, whose circumference will exceed fifty feet and which tower more than 300 feet above the ground. The General Sherman in this forest is the largest tree in the world. At its base it is 100 feet in circumference, and five feet above the ground it measures 84 feet 3 inches in circumference, and this size is maintained for probably 200 feet. Groups of six to a dozen trees 60 to 75 feet in circumference are frequently found. The tallest tree is 405 feet high, while one fallen monarch 310 feet in length reaches entirely across crescent meadow. In one of the burned trees there is a space 11 feet by 6 feet 7 inches, and twenty-two people can stand shoulder to shoulder around the inside. The altitude of the spot where the General Sherman stands is 7100 feet, and the forest will range from 6500 to 7400 feet in elevation. The other trees growing in the forest beside the *sequoia gigantea* are sugar pine, silver fir, cedar, yellow pine and Douglass pine. They all grow to immense size and are veritable monarchs of their kind.

Then as to the trout streams. Did you ever catch trout that were of golden color? Not a dull lifeless golden, but the flashing beautiful color of the pure gold itself? In Golden Trout Creek, near the base of Mt. Whitney, you can catch them, and nowhere else on this globe can you find them. More than that, in every stream from the smallest rivulet to the roaring Kern River you can catch mountain trout in almost unlimited quantities.

Now that our case is proven, let us tell briefly in the language of one who has traveled through this nature's wild playground, what other beautiful and interesting things are found in these regions.

"Four hours' ride from the Giant Forest are the lovely Alta meadows, nearly 10,000 feet above the level, brook bordered meads, deep in grass, brilliant with wildflowers. And here, while the unsaddled beasts crip the tender herbage and Master Cook bestirs himself in the camp, pitched under yonder tamaracks' pleasant shade, we will go out upon this projecting rock and look upon such a spectacle as is not matched elsewhere in all the beautiful world. Panoramic Point, they named it well who first stood here, enraptured, and gazed upon the wondrous scene. There, bathed in the splendor of the falling sun, are the mighty Kaweah peaks, towering 14,000 feet in air. In yonder wild and jagged peaks, high above the clouds, the Middle Kaweah has its sources. There to the north are the lofty Alta peaks; and here to the south old Saw Tooth looks down upon the Mineral King Range. Yonder is Farewell Gap and the marvelous Castle Rocks. There is Panther Peak in the west, and Moro Rock keeping its sentinel watch over the giant forest. And down, down, a thousand feet below us, are Sugar Loaf and Little Blue, huge domes that seem from where we gaze, perched on the edge of the great world's roof, like giant footstools, flung down on the big floor of the universe. Yonder winds away to the west the Kaweah's silver stream. See, upon the canyon's steep sides, how the green and white of the snow field and meadow gleam in the sun light; and look how over those sheer cliffs leap a hundred glistening falls. Far up their slopes hill and mountain are cloaked in fern and flower and forest; innumerable pillars, columns, domes and spires of granite greet at each turn the gaze, and over all the dying sun rolls its full tide of splendor.

"At Panoramic Point many will stop, nor further seek delight; but for those who love to seek Nature in her stern fastnesses, there remains yet the journey to the canyon of the Kern River and the ascent of Mt. Whitney, and the return by way of Golden Trout Creek.

"It is a three days' trip, with camping outfit, from Panoramic Point to the lakes at the mouth of the Kern Canyon. The Little Kern and its tributaries afford the finest trout fishing imaginable, and here the sportsman will long linger, making the record catches which shall stir the envy of many a club room circle, when the wine and tales of brave sport go round together. Thirty miles north and south, and straight as a bee's flight, the Kern Canyon runs, its precipitous walls towering to heights of 3000 to 6000 feet. The swift river cleaves the long floor, covered with giant growths of tamarack and pine, broken here and there by green meadows. All the way up the canyon an ever shifting panorama of the picturesque greets the eye. Beyond Funston's meadow the most beautiful waterfalls are frequent. The Chagoopah Fall leaps down 3000 feet, its waters dashing to spray as they rebound from rock to rock. In the short space of less than four miles are six ribbon falls, leaping sheer 3000 feet from cliff to canyon floor."

Here are illustrated in pen picture every requisite for success in the generation, transmission and distribution of electric power—the snow clad ranges that reach to dizzying altitudes, the sources of water supply of vouchsafed abundance and constancy because of matchless forests, the vast empires of most prolific orchard and vine-

land only awaiting the touch of the magic wand of irrigation to cause them to spring into unequalled productiveness —the irrigation which, by the way, transmission accomplishes best. Then there are the more familiar industrial conditions tending to normal development—the virgin soil, the sparcity of settlement, in brief the undeveloped resources, immeasurable in themselves and small only in the hold which they have upon the attention of the general public. Add to these conditions the favoring, though perhaps hacknied, influences attributable to climate, to high-priced fuel and to the enterprise of Western men, and no one will have difficulty in discerning why electric power transmission development in the Far West has exceeded that in all other quarters of the globe, or wherein it cannot fail to become a predominating factor in the industrial welfare of the empire states of the Pacific.

---

*Static Strains in High Tension Circuits.**

BY PERCY H. THOMAS.

PART I.—CONTINUED

NATURE, CAUSES AND EFFECTS OF STATIC DISTURBANCES.

CONNECTING "Dead" Transformer to Live Line.—Figure 3 represents the portion of a high tension transformer coil connected to the line terminal. The circles indicate wires. The coil may have one or more turns per layer. The numbers on the circles indicate the order in which the current passes through the turns of the winding. The low tension winding

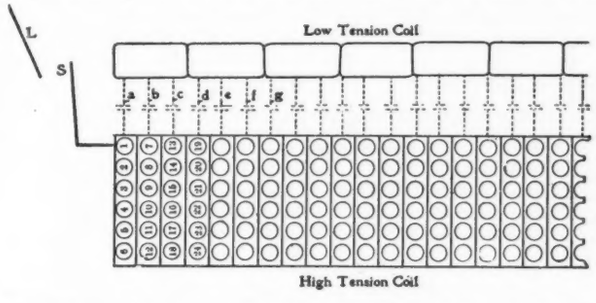


FIGURE 3.—ILLUSTRATING ELECTROSTATIC CAPACITY OF A HIGH TENSION TRANSFORMER COIL AND CHARGING FROM A LIVE LINE.

lies adjacent to the high tension and the small condensers *a*, *b*, *c*, *d*, etc., shown dotted, indicate the electrostatic capacity to the corresponding wires of the adjacent low tension coils.

Before either terminal of the transformer is connected to the line all parts of the high tension winding are at earth's potential. As the first line switch is being closed at *S* there is no change in the potential of the transformer winding until a spark passes between the switch jaws. Then instantly the potential of the transformer terminal is raised to the potential of this line wire. The rest of the high tension transformer winding also takes the potential of this line wire as soon as (but not sooner than) the necessary charge can reach *b*, *c*, *d*, *e*, etc. Now, the charges for *b*, *c*, *d*, *e*, etc., must flow through a considerable amount of inductance, which will require a length of time which is very short, but still sensible. It is clear that during this short but definite period, after the terminal has reached its full potential and before there has been sufficient time for charge to reach the inner layers, for example, *f* and *g*, etc., a difference of potential exists between the outer and inner layers of the winding which is equal to the full electromotive force of the line wire above the earth. If the insulation of the winding is too weak or the line potential is very high this momentary difference of potential will cause a spark to pass over the surface of the coil or through its insulation. This spark contains, of course, a very small amount of electricity, for as soon as the wires, etc., *f*, *g*, are charged up to line potential, the voltage between the inner and outer layers vanishes. The only result is the almost harmless passage of a nearly invisible spark.

Very soon after the closing of the first line switch the whole transformer winding will have assumed the potential of the first line wire, that is, just before the closing of the second line switch the second transformer terminal is at the potential of the first line. As the second switch is closed a spark passes and the potential of the second terminal of the transformer, which has, up to the instant, been at the potential of the first line, is suddenly changed to that of the second line—a very abrupt change. Then, as before, during the period required for the necessary change to penetrate to the inner turns, a very high potential difference is impressed on the outer portion of the coil. The momentary strain on the insulation of the coil is much greater when the second switch is closed than the first, for the first transformer terminal experienced an abrupt change only from earth's potential to line potential, while the second was changed from the potential of one line to that of the other line, which is nearly double the potential from the ground.

There is another very important difference between the effects of closing the first and second switches in connecting a "dead" transformer to a live line. In the case of closing the first, as already stated, if the momentary strains break down the insulation, and only sufficient current flows through this break to charge up the inner layers of the transformer coil. This is a very small quantity and can do comparatively little injury to the coil, especially if it be oil insulated. In the second case the amount of current passing in the static spark is not very materially greater than in the first case. But when the insulation between turns is momentarily broken down by this small spark there flows through the break a certain amount of current due to the electromotive force impressed on each turn of the coil. Although the static spark of itself would be but momentary, yet the current supported by the impressed or "normal" electromotive force of the circuit may be able to hold the arc and contine indefinitely, destroying the whole coil if not interrupted. I say may be able to hold an arc, for such an arc may or may not be held, according to the circumstances of the case. If the static spark passes when the normal electromotive force is nearly zero, or if the transformer be not able to supply much current in short circuited turns, etc., then the chance that a permanent arc will be established is small. Sparks or flashes have actually been observed in the winding of high tension transformers at the time of lightning discharges, showing actual temporary holding of an arc.

The factors which determine the minimum number of layers upon which excessive momentary potential will be impressed are, chiefly, the inductance and electrostatic capacity of the transformer coils and the abruptness of the change of potential of the terminal on the closing of the switch. The former determines the rate at which the charge can penetrate the coil, and the latter determines the time during which charging current may be passing into the coil before the full potential is reached on the terminal. The more abrupt the spark and the greater the capacity and inductance of the coils, the fewer the number of layers which will become charged before full terminal potential is reached and the more severe will be the strain on insulation.

*A paper read at the 161st meeting of the American Institute of Electrical Engineers, New York, February 14, 1902.

When switching is done on a high tension generator or a motor or any apparatus containing coils, a strain is brought in the windings near the terminals in exactly the same way as with transformer coils. There is, also, usually, this same tendency for normal voltage to cause an arc to follow any momentary break in the insulation.

It is evident that the danger from this sort of switching is greater and greater for higher and higher voltages—it is of little importance on low voltages. Actually, injury of a serious nature to apparatus from this source is very much less than would be at first expected for several reasons:

(*a*) Insulating materials will stand much higher voltages of a static nature than of a continuous nature, such as those derived from generators.

(*b*) The passing of a static spark alone is usually by no means a serious matter, and many circumstances may prevent a destructive arc from following the spark.

(*c*) It is only occasionally that the combination of circumstances arises which gives the severest conditions.

It has been assumed thus far that the potential of the line wires is unaffected by the switching operations. If, however, the connecting of the transformer to the line momentarily lowers the line potential at the switch, as will often occur, the abruptness of the static strain, and therefore its severity, will be reduced.

This discussion, which has been applied to switching on a transformer, is applicable when any coil is subjected to an abrupt change of potential in any part. For example, when a dead transmission line is connected to a live transformer the potential of the transformer terminals will usually be suddenly lowered very considerably for the moment on account of the great excess of the electrostatic capacity in the line over the transformer coil. In this case the potential of the line which must be charged directly by the generator (and not from charge previously stored in the electrostatic capacity of other lines) will rise very much more slowly since current must pass through considerable inductance in generator and transformers. Sudden short circuits, grounds, discharges of lightning arresters and similar disturbances all produce static strains more or less severe according to circumstances.

Before continuing the consideration of other cases of serious static it will be best to consider one or two more fundamental cases:

IV. When a condenser discharges suddenly through an inductive circuit containing comparatively little resistance the current in the discharge path increases continuously until the condenser is completely discharged. At this time the current, in virtue of the magnetic field which it produces, stores nearly the full amount of the energy originally in the condenser, for there is little waste, as the resistance is assumed to be small.

FOURTH LAW OF STATIC.

But this current cannot become zero until all its energy is discharged into the circuit, which in this case means into the condenser; therefore the condenser is charged to its original voltage again, but this time in the opposite direction. At the instant all the energy is thus restored to the condenser (with reversed direction) the current is zero. But the condenser cannot remain charged with the discharge path closed, and will discharge again, repeating the same phenomena; that is, the charge oscillates backward and forward through the discharge circuit. If the resistance is not zero a little energy is lost every time discharge occurs, so that each time the condenser is charged to a lower potential than the preceding time, until the whole of the energy is finally transformed into heat. If now a condenser be charged through inductance continuously, energy will be stored in the magnetic field produced by the changing current (just as in the case of discharge) until the condenser has reached full potential. All this energy must be discharged into the condenser before the charging current can cease; that is, if there are no sensible resistance losses, the condenser will be charged momentarily to double potential. The condenser will then oscillate between double potential and zero until it finally settles down at the potential of the circuit from which it is charged, which occurs only as the oscillations are damped by the resistance of the circuit or by other losses. These phenomena may be made clearer by a mechanical analogy.

The first case of the discharging condenser is similar to that of a pendulum which has been drawn aside and released; it oscillates about its final position of rest until its energy is all expended in friction. The second case may be compared to a weight supported by a spring. If the weight be dropped it will descend beyond the point at which it is finally to come to rest, stretching the spring to twice its final extension. The weight will then be drawn up again above the point of equilibrium, oscillating backward and forward until its energy is dissipated by friction. The inertia of the weight corresponds to the inductance of the charging circuit and the spring corresponds to the capacity of the condenser.

Consider the charging of a short transmission line. The line may be considered to be a condenser; assume that it is being charged from bus-bars rigidly maintained at constant potential. There will always be a certain amount of inductance in the path through which charging current must pass to reach the line, so that we have the case of the charging of a condenser through inductance with more or less resistance in the circuit. Therefore, when the line is connected, it rises to double potential (neglecting losses) and immediately starts to oscillate between this point and zero until the oscillation gradually dies out and leaves the line at normal potential.* This means that at all points the insulation of the line will receive a strain of double potential. If, on the other hand, the bus-bar from which the line is charged has not the capacity to deliver almost instantly the amount of electricity necessary to charge the line, the first effect of closing the switch will be not to raise the potential of the line to its full amount, but to make both line and bus-bar take an intermediate potential so that the line comes up to normal potential by steps. Under these circumstances the maximum of the oscillations is materially reduced, and the line is not subjected to double potential. In the extreme case in which the bus-bar has a comparatively small capacity to deliver current, the first effect of connecting the line is to bring the potential down to zero. In this case, if the line be charged from transformers, the outer portions of the windings are subjected to severe strains, as already explained. For a bus-bar to be able to supply charging current to a "dead" line so quickly as not to have its potential momentarily dropped, it must have the necessary amount of electricity already stored in condensers connected directly to the circuit. In commercial plants the place of such condensers is supplied by other live lines connected to the bus-bars.

CHARGING A SHORT TRANSMISSION LINE.

The strain of double potential produced by charging a line has an interesting analogy. If a piece of metal be tested for tensile strength by suddenly applying a weight on the end, a double strain will be momentarily given the metal due to the slight motion of the weight allowed by the stretching of the test sample. In this case the inertia of the weight corresponds to the inductance through which the line is charged.

The discussion so far assumes that there are no losses of energy in resistance or in currents set up in adjacent bodies. Such losses, which always exist to some extent, tend to reduce both the amplitude and the number of oscillations.

In the case of a long transmission line, however, the line cannot properly be considered to be a simple condenser, for this is equivalent to the assumption that the line is so short that its inductance is practically zero, and in actual long lines such is not the case. To present such a line, however, we may take a succession of choke coils and condensers connected in series, as in figure 1. Consider a single line wire open circuited at the receiving end.

CHARGING A LONG TRANSMISSION LINE.

The "dead" line is to be charged at the end, *B*, from the high tension bus-bar, *A*. Assume that, as the switch

*This rise of the line to double potential on charging was mentioned in Mr. Steinmetz's paper before the Institute last August.

at A is closed, the point B is instantaneously raised to full potential. If, now, the line extended no further than the condenser, C, we should have the case of a short line which has just been discussed; that is, the line will rise to double potential and oscillate until it finally settles down at normal potential. But since the line shown in figure 1 does not end at C, as soon as the potential of condenser C begins to rise, current begins to flow to condenser D, and as C rises higher and higher, more and more current will flow to D. The potential of D then begins to rise, which starts current to E, etc. As D rises slowly at first, C reaches bus-bar potential before D, and similarly D before E, etc. As soon as C reaches this potential it remains constant. At the same instant

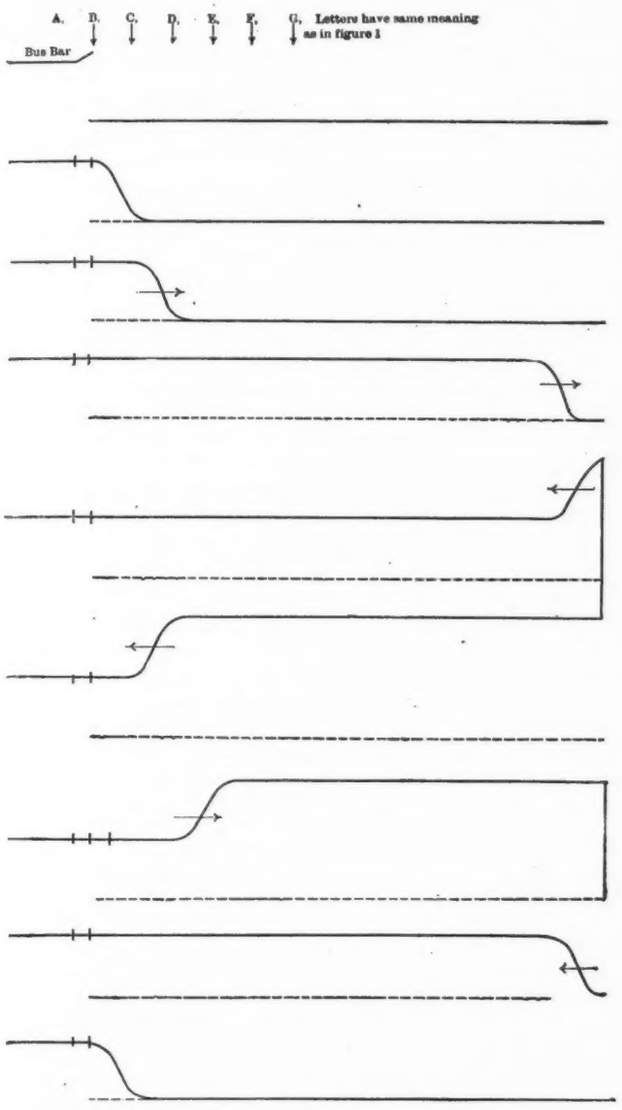


FIGURE 4—CHARGING WAVE IN A LONG TRANSMISSION LINE.

that C reaches bus-bar potential, the current value in the coil between B and C reaches a maximum and becomes constant. Similarly with the currents in the other coils. This current, which has a constant value in more and more coils as the line charges up, represents the charge that is being added constantly at those points where the potential is changing. Though the potential of C remains constant, that of D continues to rise until it reaches the same value as C, when it, too, becomes constant, though the potential of E continues to rise, and so on along the line. Similarly with E and F, but each successive condenser reaches its maximum a little behind those nearer the point A, so that the net result is a wave of electromotive force starting at the point B and passing along the line.

The general distribution of the potential of the line showing the wave form at short intervals of time after connecting on the line is shown in figure 4.

This wave passes along leaving the lines fully charged. If the line be infinitely long it will experiencence no further disturbance, and if there are no resistance or other losses the wave will pass along the line an indefinite distance, keeping its form and raising in turn all parts of the line to the full bus-bar potential. If there be considerable losses of energy as the wave proceeds (as there usually are in any actual circuit) this wave will lose its shape somewhat, and will get feebler and feebler, until, if the line be long enough, it ceases to be perceptible. This dying away of intensity may be slow enough in commercial lines, so that a large part of the original intensity of the wave will remain when the end of the line is reached. Now the end of the line is open circuited and the wave of electricity can go no further and is reflected back. At the reflecting point the maximum potential reached is twice that of the wave.

On being reflected, the wave immediately starts back along the line, leaving it charged to double potential (assuming no losses), and finally reaches the starting point, A, where its energy is absorbed by the bus-bar. But the line cannot stay at double potential, and a second wave is sent along the line, bringing it back to normal potential again. This second wave will be reflected at the open end, and will return again, but this time dropping the potential of the line to zero potential, until, as the wave reaches A again, the line is practically in its initial condition. This wave, in turn, is absorbed by the bus-bars, and the whole series of operations gone over again and again. If, however, there are resistance and other losses the wave is growing thinner and thinner all the time, and finally dies away, having only partly charged the line. As the wave dies down by the resistance losses an infinite number of small supplementary waves are sent out, which complete the charging of the line. If there are no losses, however, no supplementary waves will be found.

It will thus be seen that the charging of a long line is much the same as a short line; in both cases the line oscillates between zero and double voltage until the losses cause it to settle down at normal potential. These wave changes are indicated in figure 4.

Actual tests on commercial transmission lines suddenly charged have shown a rise of potential much greater than normal at the end farthest from the switching.

Suppose a stretched flexible cord fastened at one end and held in the hand at the other. A quick motion of the hand sideways will send a loop or wave along the cord which will pass to the end, will be reflected back and will finally reach the hand again. This wave is analogous to a static wave of the transmission line.

CHARGING A BRANCH LINE.

Consider a line consisting of two parts—the more remote having a much smaller capacity and larger inductance than the nearer. When a vave starting from the beginning reaches the junction it will be partially reflected, since the whole charge of the large line cannot be crowded into the capacity of the small line, especially in view of the increased inductance of the new position; that is, there will be a rise of potential at this point and a wave smaller than the outgoing wave will start back. As the original wave will not be wholly reflected, the potential at the juncture of the two circuits will not be double the charging voltage.

But a wave will also be sent forward into the second part of the line which will have a crest as high as the maximum of the potential at the reflecting point. Therefore, at the end of the second line, where another reflection occurs, the crest of the last wave will be doubled. The resultant potential at this point will thus be very high, but not over four times the original voltage of the bus-bar. It may be much less. This means that a branch line at the end of a main system (especially if the latter consist of two circuits in multiple) will receive a very severe shock at the farther

end when a wave enters it from the main line. This is a case that may readily occur in actual plants and should be carefully considered. If there be a third line on the end of the second leaving a still less capacity and still greater inductance a wave will be formed in this line whose crest has the value of the maximum rise of the reflecting point at the end of the second section of line, and which will double its potential at the farther end as before. This last rise of potential has as its maximum theoretical limit eight times the original charging voltage, but would actually always be much less. This case is very unlikely to occur in actual circuits. The total energy in the waves in the second and third sections of lines is much less than in the original wave, but is at a higher potential.

To return to the consideration of the uniform circuit. It has been shown that when one end of a long line is suddenly raised to a certain potential and maintained there, a wave of charge passes along the line, leaving it charged, and that when this wave reaches the open end of the line it is reflected and produces all along the line a potential double that of the bus-bar. If, however, a sine electromotive force be momentarily applied to the line so that the end of the line is not maintained steadily at the full potential, as before, but is immediately lowered, a wave will be found in the line, as before, with the same maximum voltage but

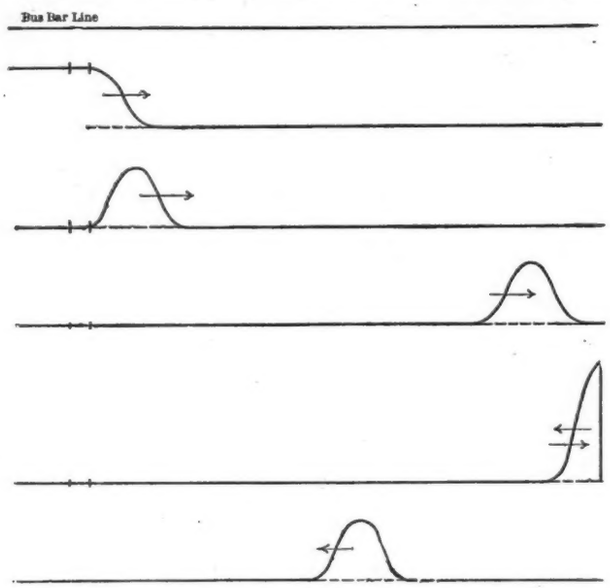


FIGURE 5.—CHARGING WAVE IN LONG TRANSMISSION LINE.

a different form (see figure 5). This wave leaves the line uncharged. The rise of potential at the reflecting point, however, is the same as long as the crest of the wave is the same, but in this case only the reflecting point receives double potential (assuming that only a single wave is started in charging).

If a wave be started at one end in a very long narrow trough of water, it will proceed the length of the trough and on reaching the end will be reflected and will rise up to double height at the reflecting point. This wave in the water is again analogous to the wave of charge passing along the line, leaving it unchanged and causing a double strain at the reflecting point.

In all cases of static effects the change in electromotive force of the bus-bars due to the generator is so slow that the generator electromotive force may be considered constant while the static phenomena are taking place.

The length of the wave in the line is determined by two factors —the speed at which the charge passes along the line and the time required to bring the potential of the first point of the line to full potential; it is the extreme distance to which the charge has penetrated when the charging potential becomes stationary.

If the line is shorter than the length of the wave no complete wave will be formed, but reflection will produce the same rise of double potential at the end. The speed at which the wave will pass along the line is inversely proportional to the square root of the product of the capacity and the inductance per unit length (unit length = 1 earth quadrant = 6200 miles), that is, to the time constant. But on air lines the waves always travel at approximately the speed of light, so that there is an inherent relation between the inductance and capacity of an air line which at first thought is very surprising. This relation is expressed by the equation $v = 1/\sqrt{L\,C}$, or $L = 1/v^2\,C$ where v is the velocity of the wave in air.

Evidently the more sudden the disturbance the more likely is the formation of a complete wave. In the extreme case when the length of wave is very much longer than the line (as in the case when the voltage is applied to the line very slowly) there is practically no wave formed, and we have the plain charging of a condenser. This is also the case considered in discussing the charging of a short transmission line.

If the source of electromotive force from which the line is charged cannot maintain rigidly its potential during charging, the line will be charged up by steps, as already explained. The result is that a weaker wave is obtained, followed by a second wave as the bus-bar recovers its potential—which completes the charging of the line.

What has just been said of charging a line applies equally well to an underground cable, only the cable has a much larger electrostatic capacity and a smaller inductance than the transmission line. If a wave of potential be formed in charging the cable, the wave will be reflected at the end, causing double potential all along the cable as it returns to the starting point. If, however, the cable be so short that no wave be formed the cable will be charged like a short line, that is, as though it were a condenser. As before, if a momentary impulse up and down be given the cable instead of a steady charging voltage, a wave of the form shown in figure 5 will be produced which causes double potential at the end of the cable and there only when but one impulse is sent into the cable.

CHARGING A MULTIPLE CABLE.*

If a steady alternating electromotive force is applied to the line, waves will be sent along having crests of positive and negative values alternately, and will be reflected at the end of the line one after another and return toward the starting point. When a returning positive crest meets an advancing positive crest double potential will result at the point of meeting; similarly with two negative crests. When a positive and a negative crest meet, zero potential will result at the point of meeting. The result is the formation of nodes and loops in the line or cable, that is, points of zero and of double potential as shown in figure 6, where advancing waves are shown full, reflected waves dotted, resultant nodes and loops in dot and dash.

The waves sent into the line by the alternating electromotive force are in continuous motion back and forward, but the nodes

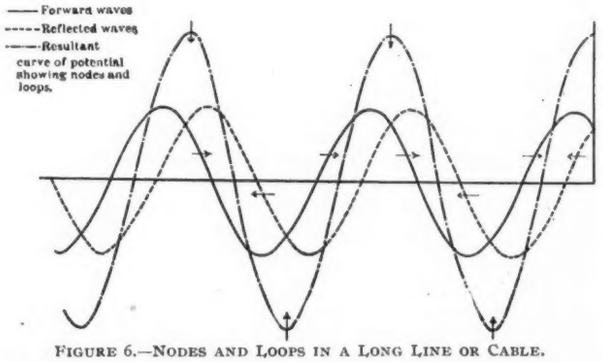


FIGURE 6.—NODES AND LOOPS IN A LONG LINE OR CABLE.

and loops are fixed in position, though the loops vary in strength, alternating between positive and negative. This phenomenon is

*By multiple cable is meant a cable containing two or more insulated conductors.

similar to the formation of nodes and loops in an organ pipe. There is always a loop or point of double potential at the reflecting point. The distance between two positive loops at any instant is the wave length of the moving waves.

To this point the lines and cables may have been considered as open circuited at the farther end. Comparatively little difference will result in static effects, however, if they be closed through transformers at various points, for the inductance of the transformer winding is so great that the comparatively large quantities of the charge on the line would not be materially lessened by the electrostatic capacity of the transformers. In fact the transformer is subjected to a very severe strain without its being able to relieve the line. This strain is similar to that produced by connecting a "dead" transformer to a live line, since the rise of potential of the transformer terminal, due to reflecting the wave, may be very abrupt.

OPENING A HIGH TENSION CIRCUIT.

When opening a load current in a high tension line or cable no rise of potential will result unless the current be suddenly interrupted. With such an interrupter, of course (as all commercial circuits contain considerable inductance) a rise of potential will result, its severity depending upon how suddenly the current is interrupted, how much magnetic energy is stored in the circuit, and how much electrostatic capacity exists in the neighborhood of the break. This matter was treated by Mr. Steinmetz last August.* He there states that an excessive rise of potential may be expected from the interruption of short circuits. As a matter of actual experience it is the opinion of the author that little harm actually results from the opening of load or short circuit currents in commercial systems, as the resulting arc cannot drop out suddenly on account of the great amount of heat generated. There are often, however, other causes of static strains which may result from short circuits, that occur at practically the same instant of time and in some cases the results of one cause may be assigned to the other.

However, by opening an unloaded line or cable, it is entirely possible to obtain a rise of potential as follows: On opening a switch to cut out an unloaded line the arc of the charging current tends to drop out when the current strength is zero, that is (since the unloaded line takes a leading current), when the voltage is a maximum, for, as the line will momentarily hold its charge, there is at this time a little difference of potential between the line and bus-bars, even after the switch is opened. The line is thus left charged when the switch is opened, while the potential of the bus-bars is changing with the generator electromotive force. When the voltage of the generator has passed through one alternation there will be a potential between the line and bus-bars which may be sufficient to cause the arc to establish itself again and recharge the line. The arc will again drop out when the current becomes zero, and this action may be repeated several times before the line is finally clear. The sharp crackling sound often accompanying the switching out of a high tension line or cable suggests this phenomenon. This recharging of the line will cause the formation of a wave and the consequent rise of potential, as in the case of charging a line. Thus, pulling off an unloaded line may have the same effect as charging it, so far as the static rise of potential is concerned.

In the case where one terminal of the single-phase generator is grounded and charging current is opened at the other a static wave is produced in the line of double the intensity caused by charging the line "dead," that is, a strain of double line voltage.

(Continuation in the ensuing number.)

"The West Coast should be proud of its electrical development and its JOURNAL OF ELECTRICITY, POWER AND GAS," writes Mr. C. W. Taintor, Schenectady, N. Y.

*Transactions of the American Institute of Electrical Engineers, August, 1901.

PERSONAL.

WILLIAM W. HANSCOM is a young man whose personality may be accepted as representative of the energy and development of engineering in the Golden State—engineering wherein the energy evidenced is little short of marvellous and wherein the development attained has been as rapid as it is thorough and original. Born in San Francisco in December, 1868, he has always lived there, for at its public and private schools he received his early education, and in its shops and manufactories he has received the extended experience which has been the foundation of his success. Leaving the high school in 1883, he began a mechanical engineering course in the National Iron Works, of San Francisco, where he spent three years in the foundry, pattern and machine shops, after which a further course of two years in the machine shop of the famous Union Iron Works completed his practical apprenticeship.

W. W. HANSCOM

His ability was promptly recognized in his appointment as assistant to the mechanical engineering superintendent of the Union Iron Works, and this position was held until the summer of 1890, when he entered the draughting office as assistant to the engineering chief. In the meantime, during his practical apprenticeship, his studies were pursued in the evening school of mechanical drawing and under his father, Mr. W. W. Hanscom, who was one of the best known mechanical engineers of California at that time.

In 1886 he became interested in electricity, his first efforts in that science being along the line of the telegraph. A substantial evidence of this early interest on his part still remains in most robust form. It was in that year he built some telegraph instruments as well as a social telegraph line which soon grew to be over twelve miles in length, with a list of forty members. A few months sufficed to make him an expert telegraph operator, and seeking other experiences in electrical works he was placed in charge of the electric light plant of the Union Iron Works. His experience in this direction is a recital of the growth of the electrical department of the Union Iron Works, which has been told heretofore*, for from 1887, when its first dynamo was installed, its growth has been probably unequalled by that of any other manufacturing industry on the Pacific Coast. During the early periods of the existence of the electrical department, as well as while he was in the draughting room, Mr. Hanscom made many efficiency tests of engines and boilers in addition to his electrical work, but in a comparatively short time the latter became of sufficient magnitude to require his entire attention.

Some reference to the work which came under his supervision as chief electrical engineer of the Union Iron Works will show that no exaggeration of the importance of the position has been made. Mr. Hanscom designed and constructed the 10,000-horse-power switchboard for the Bryant street power house of the Market Street Railway Company, of San Francisco, installing it, together with its entire equipment of generators and auxiliary electrical apparatus. He has installed a number of isolated electric lighting plants, as well as nearly sixty electrical equipments on ships of the United States navy and the merchant marine, beginning with the cruiser Charleston, which was under construction in 1887, and including such ships as the San Francisco, Monterey, Olympia, Oregon, Marietta, Farragut, Wisconsin, Hancock, Sherman and others.

In 1896 the Union Iron Works began the manufacture of the electrical apparatus required along every line of its work, with the result that at the present date all that is required in the line

*"Electricity in the Union Iron Works," in THE JOURNAL for June, 1901, Volume XI, p 111.

of generators, motors, switchboards, steering gears, ammunition hoists, turret turning gears and ventilation apparatus, together with all bell, annunciator, signal and telltale apparatus is designed and built on the grounds. At times the electrical department operates 300 or more employees and its contracts on hand at one time have reached an imposing figure. And all the while the steam plant at the works has been being gradually superceeded by electrical power so that now all the cranes and tools are being operated by electric motors which have been designed by Mr. Hanscom and built on the ground to meet the special requirements.

Personally Mr. Hanscom is the most agreeable of fellows and the most wholesome of companions, and though his companionship is greatly demanded, his preference is for quietness and the seclusion of his private laboratory at his home, where he is splendidly equipped for electrical and chemical research. During the past four years much of his spare time has been spent in perfecting methods of, and apparatus for, the manufacture of storage batteries, and that his labors in this direction have not been in vain is shown by the fact that a set of batteries which he built and sent to London in 1899 took the gold medal at the Agricultural Hall Exhibition for commercial efficiency, after over six months' practical use in a Riker cart. It is worthy of note, further, that this same set of batteries is in use at the present time.

Mr. Hanscom is a member of the American Institute of Electrical Engineers and several other engineering societies, has served as expert in a number of engineering tests of various descriptions and was for a year a member of the Board of Electrical Examiners for the Civil Service Commission of the City and County of San Francisco.

EDWARD C. JONES, whose engineering ability and charming personality have made him the idol of at least the gas lighting fraternity of the Pacific Coast, and whose portrait appears as the frontispiece of the present number of THE JOURNAL, is a true blue Yankee, having been born in the good city of Boston, Mass., on February 8, 1861. More than this, if there be such a character as a true-blue gas man, he is representative of it, for his grandfather and his father were gas men from the earliest days of the industry in New England. His father, Mr. Edward Jones, built the first gas works at Lowell, Cambridge, Worcester, Providence, Richmond and other cities, and, as will be shown, the son has more than upheld the family traditions in gas engineering throughout an unusually busy career.

When sixteen years of age the subject of this sketch entered the employ of the South Boston Gas Light Company, or to speak more exactly, his services with the company named began on January 1, 1877. His rise in the intricacies of the coal gas making processes of the time was rapid, and within two years he had invented the "Jones Jet Photometer," an instrument of such surprising simplicity that it not only sprung into use as an invaluable adjunct to every gas plant throughout the world, but, more than that, it made a name for its inventor which will go down in perpetuity in the annals of gas engineering. This proud distinction was achieved when Mr. Jones was but 18 years old. At 20 he was clerk of the corporation which employed him, and at 22 he was appointed assistant superintendent of the South Boston Gas Light Company, in which position he remained until 1885. Still continuing in the services of the Boston Gas Light Company, he became its superintendent on March 8, 1889, and on January 27, 1890, was appointed assistant engineer. In the meantime he was trustee of the Massachusetts Charitable Mechanic Association for eight years and a director of the New England Association of Gas Engineers from 1889 to 1890, while in 1890 he was elected a member of the Boston Art Club. His next move was Westward, and on May 1, 1891, he assumed the duties and responsibilities of assistant engineer of the San Francisco Gas Light Company, and in 1898, sometime after the San Francisco Gas Light Company had become merged with the Edison Light and Power Company, and known as the San Francisco Gas and Electric Company, Mr. Jones became engineer of the last named concern. The immediate cause of his coming to San Francisco was found in the necessity that the services of some one be obtained who would be fully competent to take charge of the construction of the North Beach station of the San Francisco Gas and Electric Company, and during this work his unusual ability as a gas engineer became so manifest that thenceforth his services grew to be regarded as invaluable by the company. So marked is the esteem with which he is held by the board of directors of the San Francisco Gas and Electric Company, that when he resigned from its service on March 1, 1902, to accept the position of chief engineer of the California Central Gas and Electric Company, the Board of Directors presented him with a large oak chest containing 163 pieces of silver. On a silver plate inlaid in the cover of the chest are engraved the names of the directors, as follows:

W. B. Bourne, T. B. Bishop, G. H. Collins, J. B. Crocket, J. P. Donahue, W. J. Dutton, Adam Grant, J. Downey Harvey, C. Osgood Hooker, Homer S. King, E. J. McCutcheon, L. T. Monteagle, D. T. Murphy, A. H. Payson, George W. Prescott, Rudolph Spreckles and Levi Strauss.

The following beautifully engrossed resolutions accompanied the present:

Resolved, That the board of directors of this corporation accept with sincere regret the resignation of E. C. Jones as engineer of the company, to take effect March 1, 1902; and be it further

Resolved, That this board in parting with Mr. Jones desires to express its appreciation of his eminent ability in his profession, of his most valuable services to this company while in its employment, and of the untiring energy and unselfish devotion which he has displayed during his long connection with it; and be it further

Resolved, That the best wishes of this corporation will go with Mr. Jones in all his future undertakings.

During Mr. Jones' incumbency with the San Francisco Gas and Electric Company he found time to superintend the construction of many gas plants both East and West, as well as to act in a consulting capacity for many gas enterprises. His inventions, moreover, are not a few, for in addition to his jet photometer, a list of his inventions includes such important ones as those of sounding bars for finding leaks in pipes, safety devices for gas or air pipes, besides improvements in the manufacture of gas and improvements in gas fired boilers. His literary efforts have also been equally varied and far reaching, for among others he is author of "An Experience With Naphthalene Deposits," "The Relation of Intensity of Light and Visual Perception," "The Elements of Gas Analysis," "Leakage and Condensation," A Ton of Coal," "An Easy Method of Finding the Units of Heat of Combustion," "Purification of Gas," etc.

The one subject further which should be touched upon to round out this brief sketch is that of Mr. Jones' fraternal affiliations. He has been a member of the American Gas Light Association since 1879; he is a member of the New England Association of Gas Engineers; an honorary member of the Guild of Gas Managers of Massachusetts; a member of the Western Gas Association; past president of the Pacific Coast Gas Association; and a member of the Massachusetts Charitable Mechanic Association, of the Technical Society of the Pacific Coast, and of the American Society of Mechanical Engineers. His Masonic affiliations are equally strong with those of engineering tendencies, for he is a member of St. Paul's Lodge, Boston; of St. Matthew's Royal Arch Chapter, Boston; of California Council, R. & S. M.; of Golden Gate Commandery, Knight Templars, and of Islam Temple, N. M. S., San Francisco.

WARD S. ARNOLD, at present and for some years past with the General Electric Company's Chicago office, has accepted the position of sales engineer to the Chicago office of the Stanley Electric Manufacturing Company. Mr. Arnold is well known, particularly in the West, for his genial personality and business ability, and both he and the Stanley Electric Manufacturing Company are to be congratulated upon his accension to that concerns force.

"An admirable paper." W. M. Stein, Armour Institute, Chicago.

Lombard Water Wheel Governors

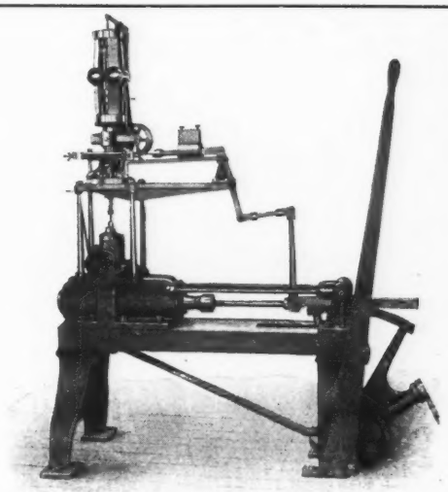
ARE GUARANTEED TO GIVE THE MOST ACCURATE SPEED REGULATION ATTAINABLE

300,000

horsepower in use

Adapted to all makes of water wheels under all operating conditions

Write for catalogue



Type F,

shown in cut, is specially adapted to Pelton and all other forms of Tangential water wheels

Estimates and drawings promptly furnished

Our 1902 Catalogue of 100 pages is now ready for distribution. It contains all available information on governing water wheels. If you are interested write for it.

THE LOMBARD GOVERNOR CO. 36 WHITTIER STREET (Roxbury District)

Boston, Mass.

Pacific Electrical Works

MANUFACTURERS INSULATED WIRE

Factory and Offices: Central Avenue and Thirty-Second Street, Los Angeles, Cal.

Weatherproof

Underwriters'

Slow Burning

Feeder Cables

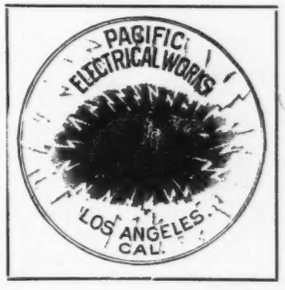
Re-covering a Specialty

Office

Magnet

Annunciator

Prices on Application

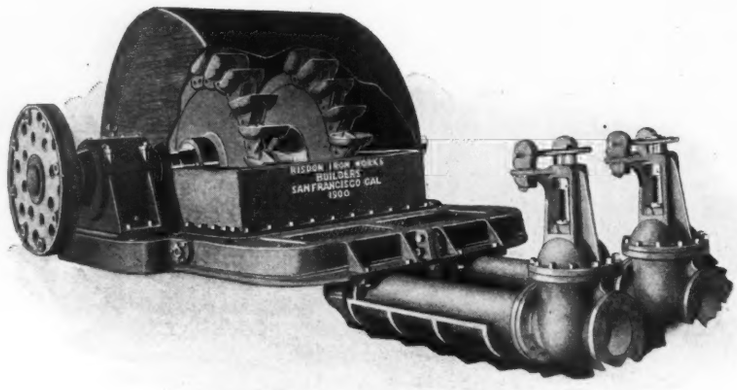


Sales Agent THE CHAS. F. SLOANE CO.

Stimson Building, Los Angeles

Mills Building, San Francisco

Tangential Water Wheels



3000-HORSEPOWER UNIT AT COLGATE STATION TRANSMITTING POWER 225 MILES

We build Water Wheels for any head and for any power. Complete electrical power generator wheels a specialty. Large wheels up to 50 feet diameter for driving compressors.

SEND FOR CATALOGUE NO. 4

RISDON IRON WORKS

Office and Branch Works, Folsom and Steuart Sts.
Main Works and Yards, Potrero.

San Francisco, California

CRIMSHAW WHITE CORE INSULATED WIRE

All our Wires—New Code Standard

NEW YORK INSULATED WIRE COMPANY

Write for our new catalogue

Main Office, 13-17 Cortlandt Street, New York

JOHN R. COLE, Sales Agent,
33 Second Street, - - - - - SAN FRANCISCO

GRAPHITE PRODUCTIONS

Graphite Resistance, Graphite Brushes, Graphite Paint
Graphite Crucibles . . Graphite for all Purposes

JOSEPH DIXON CRUCIBLE COMPANY

Factory and Home Office: Jersey City
304 Market Street, SAN FRANCISCO

GILLESPIE'S INSULATOR PINS

This pin is made of seasoned eucalyptus, a wood particularly adapted for electrical insulating. Experts declare it the best pin made. In use in most of the electrical transmission plants on the Pacific Coast. We are making pins for the Standard Electric Company, the Bay Counties Power Company, Jno. Martin & Co., and many others. Address,

Hardwood Planing Mill Co. SAN JOSE, CAL.

Have you seen a copy of the new edition of

The American Telephone Journal

The greatest telephone paper ever published. Articles of practical interest to the whole industry. Instructive to all, from the president to the operator.

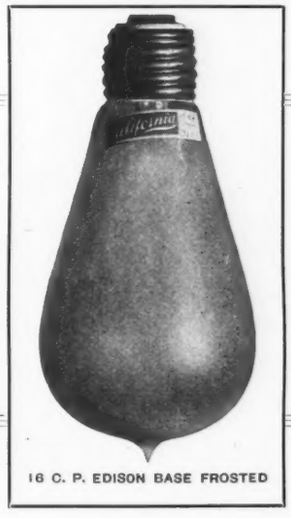
$200.00 IN CASH OFFERED IN PRIZES

Send for Sample Copy — The American Telephone Journal — 116 Nassau Street City of New York

California Lamps

are the

Lamps of the West



16 C. P. EDISON BASE FROSTED

All Voltages
All Wattages

All Candlepowers
All Filaments..

In stock ready for immediate shipment and the prices are right.

Manufactured by

California Incandescent Lamp Company

509-511 Howard Street, : : : : SAN FRANCISCO

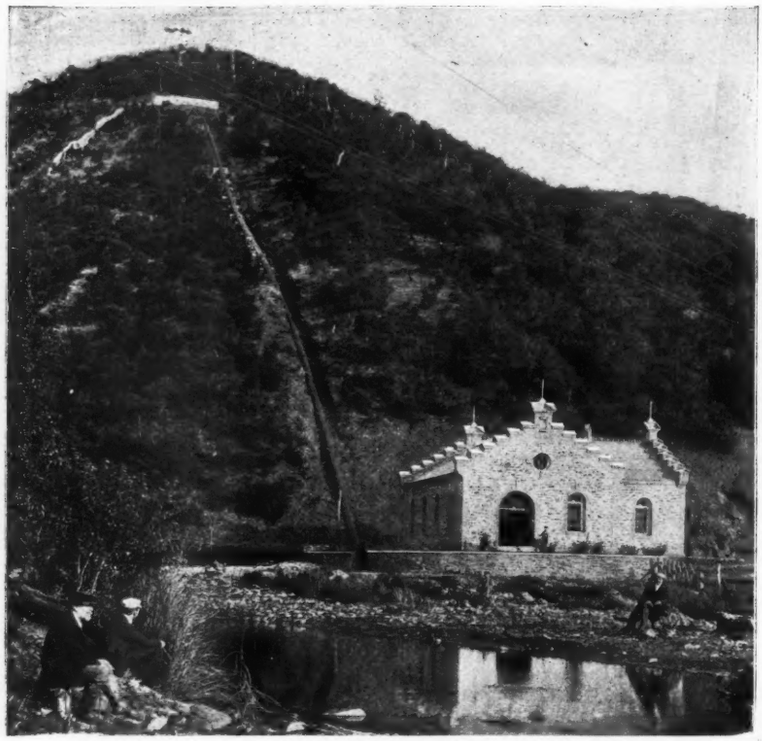
THE CHAS. F. SLOANE COMPANY,

General Sales Agents

MILLS BLDG., *SAN FRANCISCO*

THE PELTON WATER WHEEL CO.

125-129 Main Street, San Francisco, Cal. 143 Liberty Street, New York, N. Y.



A TYPICAL ELECTRIC POWER STATION, EQUIPPED WITH PELTON WHEELS, SHOWING INTAKE AND PIPE LINE ON HILLSIDE.

HIGH EFFICIENCY

AND

RELIABILITY

are the most important qualifications of a water wheel.

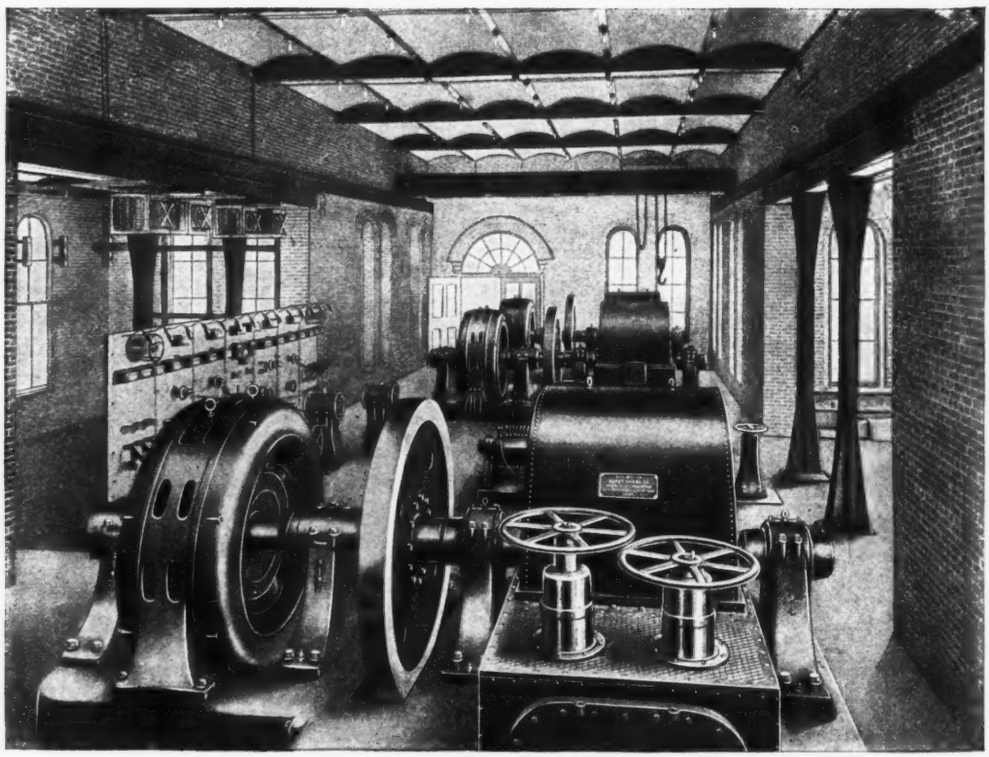
THE PELTON

possesses both and is adapted to every variety of service.

OVER 10,000 IN OPERATION

SEND FOR CATALOG.

ELECTRIC POWER TRANSMISSION



INTERIOR VIEW OF POWER TRANSMISSION PLANT, CONSISTING OF THREE 750-KILOWATT GENERATORS, DIRECT CONNECTED TO PELTON WHEELS, OPERATING UNDER 1000 FEET HEAD.

When writing advertisers kindly mention "The Journal of Electricity, Power and Gas."

Back Numbers of "THE JOURNAL" Are in Demand

Six months' prepaid subscription to THE JOURNAL will be given for the receipt of each and every copy of THE JOURNAL appearing in the list which follows. The copies should be unmutilated (suitable for binding) and delivered as below.

1895—July.

1896—April, July.

1897—April, May.

1899—January, May, September and November.

1900—January, February and May.

1901—July, August and October.

Look over your files; a lot of any copies of THE JOURNAL given in the list may pay your subscription for several years to come.

THE JOURNAL OF ELECTRICITY POWER AND GAS

144 Union Square Avenue SAN FRANCISCO, CAL.

Worthington Pumping Engines and Hydraulic Machinery

HENRY R. WORTHINGTON

Electric and Power **PUMPS** Pumping machinery for all duties

OFFICES:

New York, Boston, Philadelphia, St. Louis, Chicago, Cleveland, Indianapolis, San Francisco, London, Paris, Berlin, Vienna, Amsterdam, Brussels.

Hydraulic Works at Brooklyn, N. Y. and Elizabethport, N. J.

PACIFIC COAST BRANCH OFFICE: 132-134 FIRST STREET, SAN FRANCISCO

Telephone, MAIN 5680 Address all communications to HENRY R. WORTHINGTON

LOCAL AGENTS: Moran Bros. & Co., Seattle : Tatum & Bowen, Portland : Baker Iron Works, Los Angeles

BUYERS' DIRECTORY.

Aluminum
Pittsburg Reduction Company.

Arc Lamps
California Electrical Works.
General Electric Company.
Westinghouse Electric & Manufacturing Co.
Stanley Electric Manufacturing Company.

Attorney-at-Law
Medina, Frank P.

Batteries
California Electrical Works.
Electric Storage Battery Co., The
Sloane, Chas. F.

Boiler Compounds
Crosscup, I. O.
Dearborn Drug and Chemical Works.

Carbons
Sloane, Chas. F.

Chemicals
Dearborn Drug and Chemical Works.

Dynamos and Motors
Bullock Electric Manufacturing Company.
California Electrical Works.
Crocker-Wheeler Company.
General Electric Company.
John Martin & Co.
Northern Electrical Manufacturing Company.
Sloane, Chas. F.
Stanley Electric Manufacturing Company.
Westinghouse Electric & Manufacturing Co.

Electrical Supplies
California Electrical Works.
Electric Storage Battery Company.
General Electric Company.
John Martin & Co.
Joseph Dixon Crucible Company.
Sloane, Chas. F.
Stanley Electric Manufacturing Company.
Westinghouse Electric & Manufacturing Co.

Educational
Heald's Business College.
Van der Naillen School of Engineering.

Engineers
Bates, Frank H.
Benjamin, E. H.
Century Electric Co.
Cobb, Edward S.
Doble, Robert McF.
Hall, Leon M.
Hunt, A. M.
John Martin & Co.
Masson, R. S.
Meredith, Wynn
Ridley, A. E. Brooke.
Westinghouse, Church, Kerr & Co.

Gas Engines
Westinghouse, Church, Kerr & Co.

Governors
Lombard Governor Co., The

Instruments
California Electrical Works.
General Electric Company.
John Martin & Co.
Stanley Electric Manufacturing Company.
Stanley Instrument Company.
Weston Electrical Instrument Company.
Westinghouse, Church, Kerr & Co.

Incandescent Lamps
California Electrical Works.
California Incandescent Lamp Co.
General Electric Company.
John Martin & Co.
Sloane, Chas. F.
Westinghouse Electric & Manufacturing Co.

Insulating Compound
New York Insulated Wire Company.
Paraffine Paint Company.

Line Materials
Knowles, C. S.
Locke, Fred M.
John Martin & Co
Sloane, Chas. F.

Pull Boards
Crouse-Hinds Electric Co.

Poles, Cross Arms and Pins
Carter & Co., Geo. E.
Hardwood Planing Mill Co.
Union Lumber Company.

Power Transmission
Bullock Electric Manufacturing Company.
Crocker-Wheeler Company
General Electric Company.
Northern Electrical Manufacturing Company.
Stanley Electric Manufacturing Company.
Westinghouse Electric & Manufacturing Co.

Pipe
National Tube Company.

Pumps
Jackson Machine Works, Byron.
Moore & Co., Chas. C.
Worthington, Henry R.

Railway Supplies
General Electric Company.
John Martin & Co.
Sloane, Chas. F.
Stanley Electric Manufacturing Company.

Steam Boilers
Babcock & Wilcox Company.
Jackson Machine Works, Byron.
Oakland Iron Works.

Steam Engines
Jackson Machine Works, Byron.
Moore & Co., Chas. C.
Oakland Iron Works.
Westinghouse Machine Company.

Switches—knife
Crouse-Hinds Electric Co.

Telephones
California Electrical Works.

Transformers
General Electric Company.
Stanley Electric Manufacturing Company.
Westinghouse Electric & Manufacturing Co.

Water Wheels
Doble Company, Abner.
Knight & Company.
Oakland Iron Works.
Pelton Water Wheel Company, The.
Risdon Iron Works.

Wires and Cables
California Electrical Works.
John Martin & Co.
New York Insulated Wire Company.
Okonite Co., Ltd., The.
Pacific Electrical Works.
Pittsburg Reduction Company.
Roebling's Sons Co., The John A.

P.&S. PORCELAIN GOODS

BEAR INSPECTION

There are none better

San Francisco Deliveries Right Prices

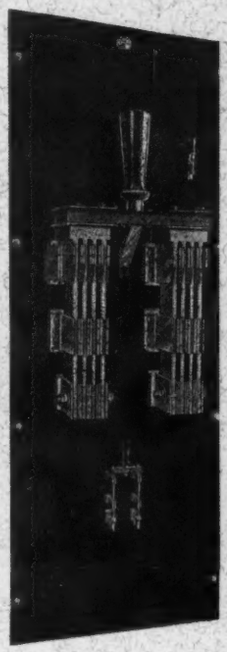
Pass & Seymour, Inc.

Solvay, New York

THE CHAS. F. SLOANE CO.,

Pacific Coast Sales Agents Mills Bldg, SAN FRANCISCO

"CROUSE-HINDS"



SWITCHES

BIG AND LITTLE

BUT ALWAYS

High-Grade

Cut shows 7500 ampere KNIFE SWITCH on 6'6" slab. Operated by one man.

CROUSE-HINDS Electric Co.

Main Office and Works: Syracuse, N. Y.

THE CHAS. F. SLOANE CO.

Pacific Coast Sales Agents

Mills Building SAN FRANCISCO

SAN FRANCISCO DELIVERIES ARE INSTANT DELIVERIES

Immediate Shipments from San Francisco stock are made on Orders for the Products of

CROUSE-HINDS ELECTRIC CO.,	Knife Switches
PASS & SEYMOUR	Porcelain Goods
HEMINGRAY GLASS CO.,	Provo-type Insulators
STANDARD UNDERGROUND CABLE CO.,	Wires and Cables
HART & HEGEMAN MANUFACTURING CO.,	Flush Switches
SAFETY ARMORITE CONDUIT CO.,	Iron Armored Conduit
PACIFIC ELECTRICAL WORKS	Weatherproof and Magnet Wires

THE CHAS. F. SLOANE CO.

Pacific Coast Sales Agents : : Mills Building, San Francisco

Transformer Litigation.

Our attention has been directed to certain letters purporting to come from the Westinghouse Electric and Manufacturing Company referring to its suit against the Saranac Lake Electric Company and threatening our customers.

All of the letters which have come to our notice are entirely misleading. Some of them say—referring to the Stanley Patent (belonging to the Westinghouse Company) which was one of the patents involved in that suit—"The patent in question covers all transformers used for lowering the voltage of an alternating current circuit."

Such a statement is entirely without warrant in the facts of the case or the decision of the Courts. Such a contention was never put forth by the Westinghouse counsel or urged by its expert.

The facts of the case are these: The suit was based upon two patents, Kennedy Patent No. 11,031, dated September 24th, 1889, and Stanley Patent No. 469,809, dated March 1st, 1892.

The earlier patent is exceedingly broad and sweeping, and, if it had been sustained, would have covered all multiple arc systems of transformer distribution wherein step-down converters are employed. As to this Kennedy Patent, both the United States Circuit Court for the Northern District of New York and the Circuit Court of Appeals for the Second Circuit, decided against the Westinghouse Company, holding the patent to be null and void, and in so doing decided that the Saranac Company was not only entitled to use transformers for lowering the voltage of an alternating current circuit, but to do so when such transformers were in multiple arc relation. The right of manufacturers other than the Westinghouse Company to manufacture and sell multiple arc systems of distribution employing step-down transformers stands upon an impregnable basis in both of said decisions.

The Stanley Patent is of later date than the Kennedy Patent. This patent is of narrow scope; indeed, the Court held that a certain rule of practice contained therein constituted the gist of the Stanley invention set forth in the claims in suit.

We have not seen any circulars wherein it is claimed that the so-called Stanley rule is employed by this company in the manufacture of its transformers. If such a claim should be made, our reply would be emphatically that such is not the case. All transformers manufactured by the Stanley Electric Manufacturing Company are made in accordance with our own patents and without infringing in the least degree upon any patent. The manufacture of transformers like those used at Saranac was discontinued a long time ago by the company which was our predecessor, and this transformer has never been manufactured by this company.

For a number of years the Westinghouse Company has steadfastly put forth the most extravagant claims as to the breadth of scope and controlling character of the Kennedy Patent which the Circuit Court of Appeals has sustained as null and void. It must be conceded that had the Court sustained the Kennedy Patent in the Saranac suit, the Westinghouse Company would, for some years to come, have had a considerable warrant for its extravagant pretensions. As it is, the decision holding that patent null and void has changed the entire situation.

It is our intention to respect both the spirit and the letter of the Court of Appeals' decision in the Saranac case. It is, however, justifiable to inform the trade of the precise situation as above, and to correct any misapprehension due to any unwarranted claims or allegations of the breadth and scope of the Stanley Patent.

Stanley Electric Mfg. Company,
Pittsfield, Mass.

JNO. MARTIN & CO. PACIFIC COAST REPRESENTATIVES

PIONEER BUILDING, SEATTLE, WASH. 31-33 NEW MONTGOMERY STREET, SAN FRANCISCO, CAL.
511 DOUGLAS BUILDING, LOS ANGELES, CAL.